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W. E. CUMMER,

UNIVERSITY OF CALIFORNIA
EXTENSION DIVISION
COLLEGE OF DENTISTRY

Dear Doctor:

Frequent requests have been made during the last five years for Graduate instruction in various subjects by Alumni and members of the profession, but in the rehabilitation of the department since the disaster of 1906 the time and energy of the Faculty has been concentrated in placing the school upon a sound educational basis, and in improving the general facilities for teaching the undergraduate student.

Graduate Instruction The desire on the part of the College to supply the demand for graduate instruction, lying dormant for some years, is to be realized in presenting, under the auspices of the University Extension Division of the University, an annual course of lectures, with clinical demonstrations or experiments, to the profession of this State just after the mid-winter holidays.

Subject The work presented will vary each year to meet the general demand; presenting the most advanced thought in each selected field. The first subject to be presented will be Nitrous Oxide and Oxygen, Anesthesia and Analgesia.

Lecturer Dr. Charles K. Teter of Cleveland, Ohio, a recognized authority on this subject, will present the course, which will consist of five lectures and as many clinical demonstrations.

The arrangements for the course will include a general meeting at the University, and lectures to the entire class, probably during the mornings, and clinical demonstrations to sections of the class, probably during the afternoons at the Affiliated Colleges.

Time The course, to be given annually, will begin this year on Monday, January 5th, and extend throughout the week. It is planned to have a general meeting on Saturday, the last day of the course, when a limited number of interesting clinics will be presented. During the week a complimentary dinner, by subscription, will be given to the lecturer. The profession will be welcome to attend both of these occasions, whether they are members of the class or not. No fee will be charged at the clinics.

The course for 1914 will be given during the week of January 5th to 10th inclusive, and the dinner will be given on some evening during the latter part of the week, time and place to be announced later.

Fees The fee for the current session has been placed at $5. Subscriptions must be paid in advance and, owing to the limited facilities for presenting the course, the number attending will be limited to 250. Subscriptions will be entered in accordance with the order of their receipt.

You are, therefore, requested to reply by return mail, enclosing check made payable to the College of Dentistry, University of California, if you desire to enroll for the course. All checks received after the class is formed will be returned to the sender. The funds will be deposited with the Regents of the University of California, to be used exclusively for the indicated purpose.

Address Communications must be addressed to the *College of Dentistry, University of California, 1st and Parnassus Avenues, San Francisco.* A programme will be sent to each member of the class in ample time to arrange for attendance.

Very truly yours,

I. W. HOWERTH,

Director University Extension.

December 1, 1913.

UNIVERSITY OF CALIFORNIA
COLLEGE OF DENTISTRY

EXTENSION LECTURES
1

NITROUS OXIDE AND OXYGEN ANESTHESIA AND ANALGESIA

BY

DR. CHARLES K. TETER
of Cleveland, Ohio

JANUARY 5-9, 1914

WITH AN INTRODUCTION BY
IRA WOODS HOWERTH
Director of University Extension, University of California

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1915

NITROUS OXIDE AND OXYGEN
ANESTHESIA AND ANALGESIA

THE UNIVERSITY EXTENSION IDEA

BY

IRA WOODS HOWERTH

Ladies and Gentlemen:

I hope no one of you will draw an unwarranted inference from the fact that anesthetics is announced as one of the subjects of instruction during the present week, and a dose of University Extension is administered at the beginning of the course.

One of the functions of the university is to stimulate and direct educational interest. This week the dental instruction is designed to stimulate the professional and educational interest of the members of the dental profession in California, and to a certain extent to direct that interest. It is appropriate, therefore, that it has the sanction of the University; and since all the work of the University carried on primarily for the benefit of those who are not in regular attendance belongs properly under university extension, it is appropriate too, that this instruction is offered under the joint auspices of the College of Dentistry and the University Extension Division. As director of that division, I wish to express my gratification that so many of you have availed yourself of this opportunity. I congratulate you on the fact that the major part of the instruction is to be given by a man of such well-earned distinction as Dr. Charles K. Teter, and I am confident that the results of this institute, of your association, your observation, and your study, will be so obviously beneficial that a week of instruction by some prominent member of the dental profession will hereafter be a permanent feature in the programme of our University activities. In my judgment, it would be an excellent thing if there could be such meetings for members of other professions, and for the various trades—for butchers and bakers and candle-stick makers. The University Extension Division of the University of Wisconsin carried on a baker's institute in which improved methods of baking were discussed, and practical, scientific knowledge with respect to that industry was presented. Such meetings must necessarily result in great public benefit. The idea back of them is the university extension idea.

The university extension idea briefly expressed is that the university, particularly a state university, since it is usually supported in whole or in part by public taxation, should not limit itself to providing instruction for those who have the means and the leisure to enable them to attend its regular classes, but should extend its instruction to all the people af the state through university extension lectures and classes, by correspondence, and by all the other methods that have proven effective in the discovery and the diffusion of knowledge. The idea in a word is that the campus of the university is the state, and that its purpose is to promote by educational effort the intelligence, and all the legitimate activities of all the people.

The university extension idea implies and involves several accessory ideas. Among these are the following: the democratic ideal in education; the development of a social consciousness in the university itself; the promotion of economy in educational effort, and the recognition of the social value of organized effort in the distribution of knowledge, and the legitimacy of such effort as a university function.

By the democratic idea in education, I mean the conception that educational opportunities should be open to all the people, high and low, rich and poor, and not merely to a select few. This implies that the highest social well-being is to be attained through the general development of the intelligence. According to the aristocratic ideal an education, at least the higher education, should be the privilege of the few, and not the opportunity of many. The old idea of a liberal education was that it was for the *liber homo,* the free man, only; the education of the so-called lower classes was discouraged. But in a democracy all are free, and the opportunity for a liberal education should therefore be the privilege of all the people. If this be the true ideal, the university at once appears an agency to assist in its realization by stimulating other agencies, by co-operating with them, by doing whatever is necessary to be done that it can accomplish better than any other agency.

By the development of a social consciousness in the university itself, I mean the perception on the part of those within the university of the true relationship of the university to the realization of the democratic ideal—that is to say, the intimate relationship of the university to the people of the state. With this consciousness the university cannot be regarded as a cloistered institution in which a privileged few, far from the madding crowd's ignoble strife, may pursue knowledge of private interest, whether it be relevant to social needs or not; it must be regarded as a public service corporation created and maintained by the people, for the people; an institution which must be kept in closest touch with all the difficulties that confront society.

With such an ideal, and with such consciousness, there must necessarily follow an attempt to promote the economy of the effort in the education of the people, for economy is the visible manifestation of intelligence in this effort. There is the same need of economic efficiency in education as in an industrial enterprise; for, after all, the education of the people of the state is a great business. The university, therefore, the public schools, and all other educational agencies, should be coordinated and brought into the most helpful relationship. There should be no unnecessary duplication of effort; all should work together for the common end, namely, the social good, through the education of the people.

And then, finally, the university extension idea implies the necessity of the effective distribution of knowledge. Not that there should be any less attention to investigation and research. These features of university work should never be neglected. The university should lift high the torch of truth, and be always a guide and inspiration for the seekers after knowledge. It may also be said, however, that this is not inconsistent with conscious consideration of the kinds of knowledge that are of most worth. Research and investigation should respond to social needs. An investigation, for instance, of the problem of immigration in California may be just as scientific and as worthy as an investigation of the wanderings of the early populations on the steppes of Asia; and it may be of much more immediate consequence.

But, however this may be, it is obvious that the public need demands the general distribution and assimilation of the knowledge attained through scientific investigation. It is not enough, for instance, that the knowledge of an improved industrial process, or the knowledge of an effective remedy for particular diseases of plants or animals, be known to the experts or stored up in learned treatises not accessible to the public. It should be in the hands of those who are interested in such processes, or who are engaged in the production of plants and animals. Buckle, in his *History of Civilization in Europe* declares: ''In a great and comprehensive view, the changes in every civilized people are, in their aggregate, dependent solely on three things: First, on the amount of knowledge possessed by their ablest men; second, on the direction which their knowledge takes, that is to say, the sort of subjects to which it refers; thirdly, and before all, on the extent to which the knowledge is diffused, and the freedom with which it pervades all classes of society.'' This diffusion of knowledge is properly, then, one of the great objects of university extensions, and the diffusion of a particular kind of knowledge is the primary object of this week of instruction.

The university extension idea, then, is the idea of democracy in eduation, an idea of utilitarian idealism. It is not inconsistent with the highest ideals of culture. Matthew Arnold, in his chapter on ''Sweetness and Light,'' defines culture as the study of perfection and the desire to make it prevail. ''The great men of culture,'' he says, ''are those who have had a passion for diffusing, for making prevail, for carrying from one end of society to the other, the best knowledge, the best ideas of their time; who have labored to divest knowledge of all that was harsh, uncouth, difficult, abstract, professional, exclusive; to humanize it, to make it efficient outside the clique of the cultivated and learned—yet still remaining the best knowledge and thought of the time, and a true source, therefore, of sweetness and light.'' This, he says, is ''the social idea;'' and it is just this social idea, so far at least as it pertains to education, that is the university extension idea.

W. F. GUMMER,

HISTORY AND DEVELOPMENT OF GENERAL ANESTHESIA

BY

DR. CHARLES K. TETER

Mr. Chairman, and Members of the Dental Profession:

It is very gratifying to me that I have the privilege of addressing this assembly and I hope that what little I have to tell you will increase your interest in what I believe to be one of the greatest, if not the greatest blessing humanity has fallen heir to, namely, modern anesthesia.

I will not attempt to delve into ancient history and trace step by step the numerous attempts which were made to prevent or relieve physical pain, for I could not do more than speculate with the uncertainty of ignorance as to the precise methods which were first adopted for the mitigation of human suffering. The ancient Egyptians, Assyrians, and Chinese, however, were more or less familiar with many vegetable substances capable of producing pleasurable sedative and anodyne effects, and undoubtedly took advantage of these effects for practicing the rudimentary surgery of the times.

In Homer's Odyssey we find the earliest records of the uses of narcotics in the following passages: ''Presently she (Helen) cast a drug into the wine whereof they drank—a drug to lull all pain and anger and bring forgetfulness of every sorrow. Whoso should drink a draft thereof when it is mingled in the bowl, on that day would let no tear fall down, and though his mother and his father died, and though they slew his brother or his son with the sword before his face and his own eyes beheld it.''

There are references in the Bible and the Talmud to the practice of inducing stupor or deep sleep by artificial means. Herodotus also makes mention of the custom of the Scythians inhaling the fumes of hemp, the effect of which was to produce an exalted mental condition followed by a desire to sleep.

At the beginning of the Christain era Diascorides speaks of the use of narcotics for the relief of pain during surgical operations. A Chinese surgeon by the name of Hoa-tho in the third century administered a preparation of hemp for stupefying his patients during surgical operations. All of these preparations left much to be desired, however, for the patients had to be tied or held down by strong men.

It was not until the very close of the eighteenth century that our modern system of anesthesia began to be foreshadowed. Up to this time the various surgical operations had been utterly unreliable, in other words true anesthesia in the modern sense of the term had never been obtained, but the discovery of hydrogen by Cavendish in 1766, of nitrogen by Rutherford 1772, of oxygen and nitrous oxide by Priestly in 1774, marked the commencement of a new era in chemical physics and paved the way for the introduction in the medical practice of a new, precise and reliable system of introducing the most complete unconsciousness and retaining this state for any reasonable length of time without serious injurious consequences. In 1799 Sir Humphrey Davy of England, then simply an assistant in the Pneumatic Institute or private hospital of Dr. Beddoes, established for the treatment of diseases by the inhalation of various vapors or gases, commenced experimenting with nitrous oxide gas.

The same year he published an account of his researches and experiments made on himself, in which he describes the exhilarating and intoxicating effects which it produces and also the use which he made of it for relieving the pain of toothache and headache. He did not seem to have pushed it to the full extent of insensibility, as he was always conscious of his own sensations, but he carried it sufficiently far to be perfectly intoxicated and delirious. The reports of his experiments induced many to follow them and his certificate of his faith in the non-injurious effects of the gas induced its use all over the world, both for purposes of amusement and as an exhibition at lectures. On page 556 of the work of Sir Humphrey Davy occurs the following passage: ''As Nitrous Oxide in its extensive operations appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place.''

It will thus be seen that of all the remedies used up to this time none have proven satisfactory or effecutl on all occasions or even in a degree safe. Surgeons of that day did not hesitate to express their disbelief in all methods and were skeptical of ever obtaining a satisfactory method; for instance, M. Velpeau in 1839 wrote: ''To escape pain in surgical operations is a chimera which we are not permitted to look for in our day. A cutting instrument and pain in operative medicine are two words which never present themselves, the one without the other, in the minds of patients and it is necessary for us surgeons to admit their association.'' Although strong inducements existed, no real and practical advance from this state was made until the great discovery of the powers of sulphuric ether. Ether was discovered in the year 1540 by Calerius Cordus, but its anesthetic properties were not discovered until 1846 by Dr. Morton. As the effect produced by different gases and vapors became more generally known, distinct points of similarity began to appear between nitrous oxide and ether. The exhilaration and hilarity induced by the former led to the term "laughing gas." It was not an uncommon event about this time for lectures on scientific subjects to demonstrate practically the intoxicating properties of ether, and owing to the exhilarating and pleasurable sensation which the vapor produced, it became customary throughout the United States, especially for young people, to give so-called ether frolics. It is indeed to this latter circumstance that the discovery of surgical anesthesia may be traced. In 1842 Dr. Crawford W. Long, a country practitioner of Jefferson County, Georgia, administered ether vapor with the distinct object of producing insensibility to pain during a surgical operation which he performed. He lived in a community where ether frolics were common. He says they were fashionable in that part of Georgia. Insensibility was not an unknown result of the venturesome inhalation sometimes indulged in. Three operations he claimed to have performed in 1842, one in 1843, and one in 1847.

However, Dr. Long considered that his cases were virtually failures; the state of exhilaration, as he termed it, was an imperfectly anesthetic one, and on the whole he found ether impracticable, and therefore abandoned it. No one repeated Dr. Long's experiments. Not a physician or surgeon ever used ether because Dr. Long had used it, nor did mankind learn from him that anesthetic inhalations for surgical purposes were possible.

The next step in the evolution of anesthesia took place in 1844 when Dr. Horace W. Wells, a dentist of Hartford, Connecticut, saw and took advantage of Davy's predictions regarding the future of nitrous oxide in dental surgery, and major surgery. On December 10, 1844, G. I. Colton, a public lecturer whose name is identified with laughing or nitrous oxide gas, gave at Hartford one of the popular exhibitions with with he was then traveling throughout the country, of the amusing effects produced by the inhalation of this now familiar gas. On the following day, December 11, at a private exhibition held at the request of several gentlemen, Samuel A. Cooley, while under the influence of gas, ran against a settee, was thrown and badly bruised in the knee, and for the time being remained unconscious of the injury. This fact so impressed Dr. Wells, who was present, that he was led to remark that "A person might have a tooth extracted while under the influence of this gas and not experience any pain." Wells said he had a tooth which troubled him exceedingly and if Colton would fill his bag with laughing gas and go with Wells to his office he would try the experiment. Colton acquiesced. Wells inhaled the gas and one of his upper molar teeth was painlessly extracted by Dr. John W. Briggs, another Hartford dentist. After the effect of the gas was eliminated Wells exclaimed: "A new era in tooth-pulling. It is the greatest discovery ever made—I did not feel it as much as the prick of a pin."

Wells straightway followed up this personal experiment by extracting several teeth, four in all, from different individuals, and speedily entered into an informal arrangement with Mr. Cooley, who was a druggist in Hartford, to establish a business exclusively for the extraction of teeth without pain by means of nitrous oxide gas. This is the first office to my knowledge where the practice was limited to the extraction of teeth.

In the pursuance of this scheme, Horace Wells came to Boston in January, 1845, and attempted to give an exhibition of painless extraction of teeth in the presence of a number of physicians and students. Dr. Morton aided him somewhat at this demonstration. Wells administered the gas and extracted the tooth, but the patient screamed with pain and the spectators laughed at him. The failure to produce insensibility was so complete that the effort was regarded as an imposition. Wells attributed his misadventure to the fact that the gas bag was withdrawn too soon from the patient's mouth, but the true reason was that Wells, following Colton's instructions, had administered only the ordinary exhilaration dose, an amount of gas insufficient to assure anesthesia. Failing to recognize the necessity of a larger dose, Wells narrowly missed making a great discovery.

The non-success of this attempt to demonstrate was so completely discouraging that Wells went home and told his friends that the gas would not work as he had hoped and that there was no dependence to be placed upon it, inasmuch as it did not produce the same effect in all cases.

Shortly afterwards Wells gave up dentistry for other pursuits and from the date of his Boston visit he abandoned further experiments with nitrous oxide gas until his return from Europe in 1847 two years later, at which time he repeated his Boston experiment with nitrous oxide gas in the amphitheatre of the New York Hospital before distinguished physicians and surgeons, but again, although he now possessed the experimental knowledge of anesthesia produced by ether, he absolutely failed in his undertaking. On account of the accompanying asphyxia and by the inconvenience of its administration, attempts to introduce nitrous oxide into general surgery were abandoned for many years. The methods of use so largely adopted in dentistry for many years came about mainly through the operation performed with nitrous oxide for Dr. Bigelow at the Massachusetts General Hospital. The substitution of the large volume of gas contained in a gasometer for the small quantity containable in a gas bag was a vital step in the success in the use of nitrous oxide at that time. Although this was pointed out in 1848, it was not until seventeen years afterward, through the business energy of Mr. Colton, whose name has already been mentioned in connection with the early history of this gas, that this modification and many later modifications in the administration of nitrous oxide anesthesia has made it the unfailing resource for the extraction of teeth to the present time.

Colton was not a dentist nor physician, but he played an important part in the discovery of general anesthesia. He acquired an immense experience by his public exhibitions of administering nitrous oxide gas. For six months of each year from 1843 to 1863 he gave daily public exhibitions of laughing gas and sometimes three or four, usually administering it to twelve or fifteen persons on each occasion. During this long period the only anesthetic use of nitrous oxide made by Mr. Colton was in the experiment successfully tried by Horace Wells, December 11, 1844. In June, 1863, at the solicitation and in connection with Dr. J. H. Smith, a dentist in New Haven, Connecticut, Colton began the preparation and administration of nitrous oxide gas on a larger scale for what might be called the specialty of extracting teeth, and in that single month of June Dr. Smith extracted 1785 teeth. The success led Dr. Colton to remove to New York City early in July of 1863, and with the assistance of Dr. John Allen, as dentist, established the Colton Dental Association, having for its sole object the painless extraction of teeth by nitrous oxide anesthesia. During the first six months of this enterprise no records of patients was kept. Subsequently to June 1, 1867, 18,600 patients registered, with an average extraction of two and a fraction teeth a patient.

In 1865 branches of the Association were opened in Philadelphia, Baltimore, St. Louis, Cincinnatti, Brooklyn, and Boston. At that date Colton had probably administered nitrous oxide gas, or caused it to be administered, 25,000 times.

The year 1846 is memorable as having witnessed the greatest advance up to that time in the discovery of a proper anesthetic agent, for in this year came the recognition and dissemination of the fact that by the inhalation of ether vapor complete surgical anesthesia could be produced. In this year Dr. W. P. G. Morton, who was a former pupil and partner of Horace Wells, made the discovery of the anesthetic properties of sulphuric ether.

Dr. W. P. G. Morton was born in Charlestown, Worcester County, Massachusetts, August 9, 1819. After receiving a New England common-school education he came to Boston at the age of seventeen. Here he acted as clerk and salesman at various places of business, but finally took himself to Baltimore, where he began the study of dentistry in the College of Dental Surgery. In 1841 or 1842 he began business at Farmington, Connecticut. There he became acquainted with Horace Wells, an exceptionally skilled dentist with an inventive turn of mind, who was then living in Hartford. In 1842–43 these two dentists formed a partnership and established themselves in practice in Boston. This partnership proving unremunerative, it was amicably dissolved in the autumn of 1843, Wells returning to Hartford and Morton remaining in Boston, having his office at 19 Tremont street. In March, 1844, he entered his name as a student of medicine at the office of Dr. Charles E. Jackson. With his newly married wife, Morton resided in that gentleman's family during the ensuing summer. In the autumn of 1844 he matriculated at the Medical School of Harvard University, taking out a complete set of tickets for lectures in the winter of 1844–45. Necessity for self-support, however, compelled him to give his attention to his dental business, and this, together with his discovery of the use of ether, so interrupted his studies that he never graduated.

In 1849, three years after the introduction of ether, the honorary degree of M.D. was conferred upon him by Washnigton University at Baltimore.

While Dr. Morton was associated with Wells he invented a new process for fastening teeth to gold plates, but in order that these plates might be worn, all old roots had to be removed. The patients objected to this, for at that time plates were fitted and worn without the removal of the roots, as they are at the present day in some parts of Europe. Morton saw that his invention would not be practicable unless he found some way of removing the roots without pain; therefore he persistently experimented with alcohol, with laudanum in large doses of three hundred drops, with opium in powders of ten to twelve grains each, and even with animal magnetism or mesmerism, but met only with failure and discouragement.

In July, 1844, Miss Parrott of Gloucester, Massachusetts, called at Dr. Morton's office to have a tooth filled. It was extremely sensitive, and to deaden the pain he made use of some carefully prepared chloric ether, which his preceptor, Dr. C. E. Jackson, had told him he had successfully employed as toothache drops when in general practice. Its apparently beneficial effects when used upon Miss Parrott's tooth decided Dr. Morton to learn all he could about this drug which was apparently so efficacious in producing a benumbing influence when locally applied.

Morton and Wells both endeavored to deprive tooth-pulling of its agony, and Morton actively occupied himself with the subject and twice during the year 1845 he visited Wells in Hartford to inquire about nitrous oxide.

Wells and Morton undoubtedly were familiar with the fact that gas and ether produced similiar effects, for an article written by Faraday in 1818 was generally known at that time. Faraday states "When the vapor of ether mixed with common air is inhaled it produces effects very similar to those occasioned by nitrous oxide." It is natural, therefore, that whoever thought of one of these agents, either as an exhilarator or as an anesthetic, would most naturally think of the other.

In the spring of 1846 Dr. Thomas R. Spear, Jr., a student in Dr. Morton's office, described to Dr. Morton his own personal experience in inhaling sulphuric ether for amusement while a scholar at Lexington Academy. Though he found it exhilarating in a high degree, no unpleasant effects had followed its inhalation. In the course of the ensuing summer Morton undertook to etherize a gold-fish. First he thought he had killed it, but it swam away when put back into the water. He also etherized a hen and then cut off her comb without perceiving any indication of pain. He held the head of Gyp, a pet spaniel that he owned, over his hand in which he placed a piece of cotton saturated with sulphuric ether. The animal became partially insensible and was ever afterward afraid of Dr. Morton. Dr. Morton also made himself desperately sick by taking ether and opium experimentally, and on one occasion his mother found him half insensible from inhaling ether. In June, 1846, Morton arranged with Granville H. Hayden to superintend the business at his office, confiding to him as his reason for so doing that he had discovered something which would enable him to extract teeth without pain, and that the discovery would occupy all his time and attention. Early in the following August, having obtained a bottle of ether from Joseph Barnett, Morton requested Hayden to inhale this vapor. This Hayden declined to do. Morton accordingly took the ether home with him and was in the act of giving it to his former pet, the dog, when the animal, excited by the inhalation, escaped from him, upset the bottle and spilt most of its contents. Morton saturated his handerchief with what remained and breathed it himself, in deep inhalations, and a feeling of lassitude came over him followed by a complete but momentary state of unconsciousness. He said "I am convinced that in that moment a tooth might have been drawn with no sensation of pain." On the evening of September 30, 1846, a Mr. Frost, a stout, healthy man, came into Dr. Morton's office suffering great pain and wished to have a tooth extracted. He was timid and asked to be mesmerized. Dr. Morton replied that he had a better application than mesmerism and proposed to use it. Without much inquiry and on the assurance that it was safe and would destroy the pain attending the operation, Mr. Frost consented to the process. Thereupon the doctor saturated a folded cloth with ether and held it to the man's mouth and nostrils until he was unconscious. In less than five minutes after the patient had taken his seat in the operating chair the great discovery was made. It was so dark that Dr. Hayden held a lamp for Dr. Morton while the firmly rooted bicuspid was extracted, never imagining how near his assistant came to defeating the discovery on account of the inflamable vapor.

Mr. Frost quickly recovered and said he never felt so happy in his life. He even remained some time talking about the terms, and at Morton's request before leaving wrote the following certificate: "This is to certify that I applied to Dr. Morton this evening at eight o'clock suffering under the most violent toothache. Dr. Morton took out his handkerchief, saturated it with a preparation of his, from which I breathed about half a minute, and was then lost in sleep. In an instant more I awoke and saw my tooth lying on the floor. I did not experience the slightest pain whatever. I remained twenty minutes in his office afterwards and felt no unpleasant effects from the operation.'' Signed, Everett H. Frost, Boston, 47 Spring street, September 30, 1846. This is also witnessed by A. T. Kenny and J. G. Hayden, Surgeon Dentists.

Dr. Morton advised with Dr. Jackson, as well as with Dr. Hayden, in regard to the best method of bringing this discovery to the attention of the medical profession and the public. As the result of various conferences the obvious conclusion was reached that proper publicity for the new discovery could be obtained only through the agency of some leading surgeon by the performance of an impressive operation in the presence of numerous spectators. The only hospital in Boston at this time was the Massachusetts General Hospital, and Morton objected that by taking this step he was apt to disclose the nature of the articles used, as its odor was so characteristic, but he was assured that this could be effectually disguised by adding to the ether French essence. Accordingly two or three days after the first operation was performed Dr. Morton called upon Dr. John P. Warren, one of the surgeons of the hospital, and told him that he had discovered something which would prevent pain from being felt during surgical operation, and made arrangements to give a demonstration at the hospital. Friday morning was the time set for the demonstration, so Dr. Morton rose at daybreak, went to N. C. Chamberlain, a well-known instrument maker, whom by great urgency he had persuaded to undertake the task of making his inhaler. Finding this was not quite completed when he called for it, and fearing he should be late, Morton finally seized it from the workman's hands and started for the hospital, accompanied by Mr. Frost, whom he took with him to contribute in some way to Morton's relief in case of failure and to act as a voucher in regard to what Morton had already accomplished. Dr. Warren, having waited ten or fifteen minutes for Dr. Morton to put in his appearance, turned to those present and said: ''As Dr. Morton has not arrived I presume he is otherwise engaged,'' apparently conveying the idea that Morton did not intend to appear. This remark occasioned a laugh. Dr. Warren then sat down to his patient, but as he raised his knife to begin Dr. Morton entered the operating room.

Dr. Morton had been advised to tell Dr. Warren what substances he proposed to use, as it would partly divide the responsibility and he might be sure that Dr. Warren would not abuse his confidence. Dr. Morton fully intended to do so, but he arrived so late at the hospital that he had no opportunity to make the explanation at that time.

Having completed his preparation and added his French essence, Morton proceeded to administer his compound. He said to the patient ''Are you afraid?'' The patient answered him replying, ''No, I feel confident and will do precisely as you tell me.'' Pointing to Mr. Frost, Morton said: ''There is the man who has breathed it and can testify to its success.'' When the anesthetic was started the spectators looked on incredulously, especially as the patient first became exhilarated, but suddenly when his unconsciousness was evident there was a start of surprise. Dr Morton then calmly informed Dr. Warren that his patient was ready, and as the operation progressed the utmost silence prevailed, every eye being fixed on the novel scene in eager expectancy and amazement. During the latter part of the operation the patient was sufficiently conscious to move his limbs. These movements seemed to indicate the existence of pain, but after he recovered his faculties he said he experienced none, only a sensation like that of being scratched with a blunt instrument. This somewhat imperfect insensibility arose from the fact that as the operation had taken longer than was anticipated, Morton had several times removed the inhaler from the patient's face. While the patient was still lying on the table, Dr. Warren turned to the audience and said slowly and emphatically, ''Gentlemen, this is no humbug.'' But he did not consider this a satisfactory test for the anesthetic, so he invited Dr. Morton to come to the Hospital and administer it again on the following day. The patient who presented herself on this day, October 17th, was a woman with a fatty tumor of considerable magnitude on the right shoulder. Dr. Morton again administered his preparation; complete insensibility attended the removal of this growth. Dr. George Hayward, who had not been present on the preceding day, performed the operation. It occupied seven minutes; as it involved incision through the skin on a somewhat larger scale, it proved in the matter of cutting as experimentally satisfactory as an amputation would have been. No delusion of the imagination could be suggested on this occasion, and for the first time the power of the new agent was conclusively shown.

The great discovery of the new anesthetic was first made known in Europe, when Dr. Bigelow of Boston addressed a letter bearing the date of November 28, 1846, to his personal friend, Dr. Francis Boote of London. This letter announced the discovery of anesthesia by ether. Dr. Boote was a well-known physician practicing in London, and he lost no time in communicating his information to others. On December 17th Dr. Boote informed Dr. Robertson, a dentist of London, about what was being done with ether in America by Dr. Morton and others. A relative of Dr. Boote, a Miss Lonsdale, was suffering with an abscessed tooth, so Dr. Boote called Dr. Robertson to come to his house and administer ether and extract this tooth. This first attempt was entirely successful and took place on the 19th of December, 1846.

The new discovery rapidly made its way into the London hospitals with more or less success and was hailed with rapturous enthusiasm.

The great surgeon, Sir Lister, who was considered grave and sedate, could not control his language, but in a letter written on the English verification of the discovery burst forth: ''Hurrah! Rejoice! An American dentist has used ether, inhalations of it, to destroy sensations in his operations and the plan has succeeded in the hands of Haywards, Warren and others in Boston. In six months no operation will be performed without this previous preparation. Rejoice!'' The news quickly reached the continent of Europe, although it was first looked upon there with incredulity. The Great American Discovery, as it was called, finally took firm hold on the scientific world with wonderful power and unanimity.

The discovery of chloroform as an anesthetic agent took place one year after the anesthetic properties of ether had been discovered and announced by Morton. The facts leading up to the discovery of the anesthetic properties of chloroform were as follows: Dr. James Wise Simpson of Edinburgh, Scotland, who was a prominent physician and had a large obstetric practice, was one of the first to adopt ether in relieving the sting of human suffering in woman's greatest hour of peril. The odor of ether was so objectional to some of Dr. Simpson's patients that he was desirous of finding some means of obviating this, and in this connection spoke to Dr. David Waldie, analytical chemist to the Liverpool Apothecaries Company, about his endeavors to find something to supercede sulphuric ether and his trial of certain vapors, among others of chloric ether, of the chemical nature of which he was ignorant. Dr. Waldie explained to Sir James that in using this ether it was the vapor of alcohol chiefly which would be inhaled and advised him to try the chloride of formyl, or chloroform, from which chloric ether was made at the Liverpool Laboratory.

This conversation took place in October, 1847. Following up Mr. Waldie's recommendation, Dr. Simpson procured a specimen of chloroform from Dunkins & Lockhart, Edinburgh chemists, Mr. Waldie's laboratory having just then been destroyed by fire.

Dr. Simpson appears to have ascertained the anesthetic properties of chloroform during some experiments, in the inhalation of various drugs, made around the supper table late at night in his own dining-room in company with Dr. Keith and Dr. J. Matthews Duncan, some ladies of Simpson's family and a naval officer who was a brother-in-law of Dr. Simpson. An account of this adventure speaks of one of the ladies gallantly taking her place in turn, to inhale vapor as it rose from the saucer into which the chloroform had been poured from the bottle. As the result of this inhalation all three gentlemen engaged in the experiment fell to the floor in a state of insensibility. Not long afterward chloroform was adopted in the Royal Infirmary of Edinburgh and throughout the world as a surgical anesthetic.

While there was great rejoicing generally over the new discovery, there arose also determined opposition not only to the use of anesthetics but to Dr. Morton himself. And to the shame of the dental profession most of it came from men in this profession who were looked upon as leaders.

We find the following along this line, in Nathan P. Rice's book which was written in 1858: ''While Morton received many congratulations from the great and good, his success awakened the envy and excited the jealousy of some of his professional brethren, who had, for some time, regarded with disgust the large and lucrative business which he had so suddenly created and now had double cause to fear from the power which the sole possession of the new agent would give him. Among these was Dr. J. F. Flagg, who appears to have stood conspicuous in this respect, as he at once commenced a terrible onslaught on the new application of ether, and more terrible still upon the hapless discoverer. But not succeeding in his first attempt in crushing the young aspirant in his cradle and not retarding the rapidity at which the method was spreading, he at length excited his brother dentists to arouse and array themselves in order of battle. Accordingly early in December a meeting of the Boston dentists was called and a committee of twelve appointed with Dr. Flagg at the head to make a formal protest against anesthesia. This organization and systematic opposition made a formal appeal to the public against Dr. Morton's discovery through the newspaper; a manifesto which remains as a monument to perpetuate their malice was published by them in the Boston Daily Advertiser and professed to give a large number of instances in which experiments had produced unfortunate effects, though not a single name was given. Equally persevering in his attempts to render an essential service to his race by exposing the dangers of Dr. Morton's discovery was Professor A. Wescott, afterward connected with the Dental College of Boston. From the first he seemed to consider it his especial duty to declare war not merely against the use of ether itself but also against the unfortunate Dr. Morton. In a public statement from this learned and facetious professor he said: ''If Dr. Morton can make me believe that the indiscriminate application of this vapor is really so very harmless he will make me believe I am the richest man on earth. For who would not freely administer a harmless thing, especially when it is indorsed by the first surgeons and medical men of New England, to stop the crying of cross babies, if it is really harmless and the subject after breathing it for from one to two minutes drops into a quiet slumber. It certainly would be invaluable for nursery purposes.''

This is a fair specimen of the learned professor's logic and humor. However, the dental profession was not alone in their denunciation of this discovery, for Robert M. Houston, M.D., the editor of the *Philadelphia Medical Examiner*, put on his veto in this wise: ''We should not consider it entitled to the least notice, but we perceive by the *Boston Medical and Surgical Journal* that prominent members of the profession have naturally been cautioning this maker. Again he says: "We are persuaded that the surgeons of Philadelphia will not be seduced from the high professional path of duty into the quagmire of quackery by this will-of-the-wisp." Again, "We cannot close these remarks without again expressing our deep mortification and regret that the eminent men who have so long adorned the profession in Boston should have consented for a moment to have set so bad an example to their youthful brethren as we concede them to have done in this instance." From all this we can see that Dr. Morton's path was not strewn with flowers and perpetual song.

The name of Oliver Wendell Holmes is almost as intimately connected with anesthesia as is that of Dr. Morton's, and came about as follows: Long after the anesthetic agent was known to be sulphuric ether, it was still spoken of as the compound, the gas, the new discovery, the preparation, the mixture, etc. The term "letheon" commonly adopted immediately after the American patent was secured had its origin in the meeting at the house of Dr. Gould; Dr. J. H. Bigelow, Oliver Wendell Holmes, W. P. G. Morton being present. Dr. Gould read aloud a prepared list of names applicable to an article familiarly known, but now put to an entirely new use. Among these was the name "letheon." Dr. Morton upon catching the word exclaimed: "That is the name with which the new discovery shall be christened." Dr. Wendell Holmes was not pleased, however, with this name and he addressed the following note to Dr. Morton:

"My dear Sir: "Boston, November 21, 1846.

"Everybody wants to have a hand in the great discovery. All I will do is to give you a hint or two as to the name or the names to be applied to the state produced and the agent. The state should, I think, be called anesthesia, which signified insensibility more particularly as used by Linnatus and Cullen. The adjective will be anesthetic, thus we might say the stage of anesthesia or the anesthetic state. The means employed would be properly called the anti-anesthetic agent. Perhaps it might be allowable to say anesthetic agent, but this admits of question. The word antineuric, aneuric, neuro-leptic, and neurostasis seem to be too anatomical, whereas the change is a physiological one. I throw these out for consideration. I would have a name soon and consult some accomplished scholar such as President Elliot or Dr. Bigelow, Sr., before fixing upon the term which will be repeated by the tongues of every civilized race of mankind. You could mention these words I suggest for their consideration, but there may be others more appropriate and agreeable.

"Yours very respectfully,

"(Signed) O. W. HOLMES."

You are probably all aware of the fact that Dr. Morton applied for and received a patent for his invention, from this and foreign governments but he was not successful in preventing the free use of ether for anesthetic purposes.

The terms offered to dentists and surgeons which allowed them to use Dr. Morton's invention and apparatus were as follows:

Terms for dentists. In cities of

over 150,000 inhabitants		$200 for 7 years
over 50,000 and less than	150,000,	150 for 7 years
over 40,000 and less than	50,000,	100 for 7 years
over 30,000 and less than	40,000,	87 for 7 years
over 20,000 and less than	30,000,	75 for 7 years
over 10,000 and less than	20,000,	63 for 7 years
over 5,000 and less than	10,000,	50 for 7 years
And in cities under 5,000,		37 for 7 years

Surgeons' license fees to be 25 per cent of all charges made for performing operations wherein the discovery was used, the parties licensed to keep a correct account of all operations, the names of patients operated upon and to follow the same with payment as often as once in three months. This arrangement, if it could have been carried out, would have been better than the present income tax.

Time will not permit of the further perusal of the discovery and development of other anesthetic agents, and I will only refer to the first time oxygen was used in connection with nitrous oxide in the place of the atmospheric air.

Another dentist by the name of Dr. Andrew of Chicago in 1868 called attention to the fact that better anesthesia could be obtained when using pure oxygen with nitrous oxide in place of the atmospheric air. By the use of this discovery with nitrous oxide we now have an anesthetic agent which more nearly approaches the requirements of an ideal anesthetic agent than any other.

We are filled with sorrow when we think of the persecution which Dr. Morton and Dr. Wells had to endure and their untimely death. Horace Wells died in New York City January 28, 1848, at the age of 33 years. It has been stated that he opened a vein while in his bathroom and at the same time inhaled ether vapor. Dr. Morton ended his days in poverty, discouragement, and sorrow, and it is believed that he became of unsound mind as the result of this. He died July 15, 1868, of apoplexy while driving in Central Park, New York City.

The dental profession should feel justly proud of the fact that dentists discovered anesthetics first, and the introduction of anesthesia in general surgery would not have taken place when it did if it had not been for Well's experiments and Morton's determination and untiring efforts along this line. These men should be greatly honored, not only by the dental but by the medical profession as well, for they conferred upon suffering humanity a blessing not yet fully appreciated. But I think it is the universal belief that they should be classed among the greatest benefactors of the human race.

THE FUNDAMENTAL PRINCIPLES INVOLVED IN THE SCIENTIFIC ADMINISTRATION OF NITROUS OXIDE

From all that I have said in regard to the physiology of nitrous oxide anesthesia, I think you all understand the important principle in the method of the administration of nitrous oxide is its combination with oxygen. The combination of pure nitrous oxide with oxygen when properly administered is the safest, the most agreeable, and the freest from post-anesthetic complications of the general anesthetic agents now employed. It is to be regretted, however, that it is the most difficult to administer properly. The reasons for this are as follows: (1) The physical properties of nitrous oxide are such that this gas must be given from 80% to 95% pure in order that the tension of the gas in the blood may be sufficient to produce a psycho-chemical change in the nerve cells, which brings about the anesthetic state when nitrous oxide is used. Because of this fact one is consequently confronted with the problem of asphyxia, which is practically the only danger of gas-oxygen anesthesia when pure gases are employed. (2) The anesthetic properties of nitrous oxide are extremely evanescent; the patient can pass from profound anesthesia to the conscious state within sixty seconds. The extreme rapidity of induction and elimination renders its administration very difficult. (3) Muscular tone is maintained to a much greater extent than when ether or chloroform is used, it being possible to obtain the same degree of flexity of the musculature that can safely be procured with the more powerful anesthetic agents. In consequence of these peculiar properties it is necessary to utilize every known scientific principle that will enhance its efficiency, in order to make nitrous oxide practicable as an anesthetic agent.

The following fundamental principles have proved of value in the scientific administration of nitrous oxide, not only in my hands, but in others as well: (1) The administration of pre-anesthetic narcotic. (2) The use of pure oxygen. (3) The maintenance of a definite and even flow of gases. (4) The administration of gases warm. (5) The rebreathing of the gases. (6) The utilization of positive intra-pulmonary pressure. I wish to state that the administration of pre-anesthetic narcotics is not advisable, nor is it necessary when administering nitrous oxide for minor operations or for the extraction of teeth, but this applies when administering the anesthetic for major operations or for operations of a major surgical character.

The advantage of narcotic medication previous to the administration of an inhalation anesthetic is now generally recognized by the medical profession. It is doubly essential if nitrous oxide is the anesthetic employed in major surgery. The reasons for this are that the patient comes into the operating room composed and tranquil, that the induction period is shortened, more profound anesthesia is obtained with greater relaxation in proportion to the quantity of general anesthetic employed, that hyper-secretion of mucous is prevented, that cardio-inhibitory shock is obviated. None of the narcotics employed may be regarded as ideal. I have used morphine and atropine, scopolamine morphine, pantopon and atropine. It is a well-known clinical fact that two narcotics introduced simultaneously, or even one shortly after the other, have a much more powerful effect than when a total quantity of one narcotic equivalent in strength to the combination is administered. Also that a dose of one drug acts much better when it is given in relatively small quantities with an interval between each administration than when administered all at once. When the narcotic is selected and the dose determined for each individual case, the first injection should be given one hour and the second one-half hour before operating.

An article by C. Louis Leopold in the *Lancet,* February 11, 1911, on some remarks on pantopon anesthesia, directed my attention to this drug. After reading this article I secured some pantopon and since January, 1912, have been using it as a preliminary to gas-oxygen anesthesia in general surgical cases, and the results so far have been most excellent. Pantopon is a mixture of the soluble chlorides of opium. Sahli of Berne seems to have been the first to experiment with pantopon and to have it prepared. Haller, Gordon, Herman, Roderi, Raffalovitch and others have published articles concerning the usefulness of this preparation. Haller found that pantopon was well tolerated and produced none of the unsatisfactory after results that sometimes follow the administration of solutions of morphia. Herman states that it influences the respiratory centers much less than does morphia. Leopold found that the breathing throughout is regular and quiet and never shallow, except when a double dose is given and that there is no apnoea whatever. The greatest advantage I have found with pantopon in comparison with morphia is that there is far less nausea and vomiting both during and following anesthesia. In only a few of my cases have the patients retched or vomited during the course of anesthesia, and in no case has there been more than a transitory post-anesthetic vomiting.

Retching on the part of the patient during the progress of an operation is of the greatest annoyance not only to the anesthetist but to the surgeon as well. This has been quite difficult to overcome with the gas-oxygen anesthesia when a non-asphyxia stage is maintained and cyanosis is completely eliminated. In many cases it is possible to carry the patient along in a natural appearing sleep and with sufficient relaxation, maintaining only a comparative light anesthesia. This is often marred, however, by the occurrence of retching or vomiting. Vomiting will occur only during comparatively light anesthesia.

THE USE OF PURE OXYGEN

It has been stated that it is necessary to administer nitrous oxide from 80% to 95% pure in order that the blood may become sufficiently saturated to produce the anesthetic state. This being true, there is not enough oxygen available from the atmosphere in the majority of cases to make nitrous oxide respirable owing to the large percentage of nitrogen in the atmosphere. The average patient, for example, will require 88 parts of nitrous oxide to produce a satisfactorily deep anesthesia; this would leave twelve parts of atmospheric air. As the air contains only about one-fifth oxygen there will be only about two and two-fifths parts of oxygen available. Nitrous oxide is not respirable with less than seven to twenty parts of pure oxygen. Therefore, satisfactory anesthesia for general surgery cannot be obtained with nitrous oxide and atmospheric air. On a number of occasions I have been unfortunate in having the oxygen supply fail and being compelled to maintain the anesthesia with nitrous oxide and atmospheric air. Anesthesia was continued in every case until the completion of the operation; in some cases it was necessary to produce a considerable degree of cyanosis which was accompanied in some instances by more or less rigidity of muscles, and the condition of the patient was very unsatisfactory as compared with that when the pure oxygen was being used.

THE MAINTENANCE OF A DEFINITE AND EVEN FLOW OF THE GASES TO MAKE POSSIBLE ACCURACY IN ANESTHESIA

The most essential principle involved in the scientific administration of gas-oxygen is the maintenance of a definite and even flow of both the nitrous oxide and oxygen. I have called attention to the necessity of precision and accuracy of dosage many, many times, and I consider it the most essential point in producing and maintaining a safe and good surgical anesthesia. With a definite even flow of the gases it is comparatively easy to anesthetize successfully the majority of patients. When the anesthetic tension in the blood and other tissues has been established and the proper proportion of nitrous oxide and oxygen to control the individual case has been determined, it will not be necessary to change the proportion of the gases to any great extent throughout the remainder of the operation. In many cases it not necessary to change the proportion of gases at all after the first few minutes, the flow in some instances being continued without interruption for over an hour. An even narcosis is usually the result if the respiratory passages are not obstructed. The adoption of this method adds greatly to the safety and gives a relatively more profound narcosis, followed by less nausea, thereby greatly simplifying the work of the anesthetist. The gases must be under control with definite known pressure. This is accomplished with pressure regulators which are incorporated in the apparatus or attached to the large cylinders. These reduce the gases from a high to a low pressure. It is possible by this means to obtain definite known proportions of nitrous oxide and oxygen which will continue to flow in the same proportions until a change is made by the anesthetist. No definite percentage of the gases is uniformly satisfactory for different patients or for the same patient at different times. Numerous factors are responsible for this, such as type of patient, depth and frequency of respiration, obstructed air passage, reflex from surgical trauma, condition of patient, and degree of shock produced. The average amount of oxygen which I use, however, is 16⅔%. Anesthesia lasting one hour requires on an average of one hundred gallons of nitrous oxide and twenty gallons of oxygen.

Surgical[*] anesthesia for the half century prior to the past decade made little scientific progress. While the art of anesthesia advanced with the increasing demands of surgery; while the lore of the individual anesthetist was accumulated, yet each surgical narcosis was achieved according to the personal recipe of the given anesthetist. Largely because of the difficulties of confining and measuring matter in such an elusive state as the gaseous, that precision and accuracy of dosage which came to be demanded essential in the administration of liquid and solid drugs, secured no place with the volatile anesthetics. Anesthetization was accomplished according to certain empirical methods and formulae, guided by the reaction of the individual.

Granting that such empiric anesthetization in the hands of the skilled anesthetist may be ever so perfect, yet if these methods permit of no formulation, uniform results cannot be achieved, nor can methods be standardized. Further, high skill in anesthesia by these empiric methods involves a rare natural aptitude and long training. Therefore, the trend of the present is toward that exactness of dosage and perfection of delivery, that will place anesthesia on the basis of an exact science.

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[*] Connell.

THE ADMINISTRATION OF THE GASES WARM

It is an established fact that all anesthetics are safer when administered warm. Gwathmey of New York was the first to experiment on animals with warm and cold nitrous oxide. He found that nitrous oxide and oxygen administered warm was over twice as safe as when given under normal temperature, and three to five times as safe as the cold gas. Also that all anesthetics heated to body temperature are increased in value as regards life without any decrease in their anesthetic effects.

My clinical experience has substained Gwathmey's laboratory results, not only in regard to the increase safety of nitrous oxide as an anesthetic, but anesthesia is induced more quietly and more profoundly. In a series of forty cases I compared the length of time to produce anesthesia with warm and cold nitrous oxide. Pure nitrous oxide was used, and anesthesia was marked by the absence of the lid reflex and the beginning of stertorious respiration. The average time consumed in producing anesthesia with nitrous oxide at 90 degrees Fahrenheit was thirty-two seconds, and the average time with nitrous oxide at 42 degrees Farenheit was fifty-six seconds. Many of the patients to whom the warm gases were given said they were not conscious after the second or third inhalation, while most of those taking the cold gases were conscious up to the tenth and some up to the twentieth inhalation. All of these patients were women from eighteen to sixty years of age.

Warm nitrous oxide is more readily absorbed by the blood than cold gas and the resulting anesthesia is more profound. About 90 degrees Fahrenheit, in my experience, is the best temperature for inhalation. The warm gases should be at this temperature when they reach the inhaler; a higher temperature raises the body temperature two or three degrees in some instances and in some cases exhaustion will quite ferquently be noticed.

THE RE-BREATHING OF NITROUS OXIDE IN ITS ADMINISTRATION

The re-breathing of nitrous oxide is not new, having been used to a certain extent from the time of its discovery. Hewitt speaks of ''to and fro breathing,'' but I understand that his experience was confined to the use of this method only to the extent of inducing anesthesia and not to its continuous application. Many men have been using some method of re-breathing for years. To Dr. W. B. Gath, formerly of Baltimore, however, probably belongs the credit for placing the re-breathing of nitrous oxide on a scientific basis. He employed a method of re-breathing on a large number of patients at the Johns Hopkins Hospital during his interneship. I had been using the re-breathing of the gases for sometime before this, as I have used it since September, 1907, in all of my general surgical cases. Being aware of the fact that the exhalation of the patients under nitrous oxide-oxygen anesthesia contained about eighty per cent of nitrous oxide, I have utilized the exhalation as much as possible, still keeping the tension of the nitrous oxide up to the extent necessary to produce surgical anesthesia, and allowing enough oxygen to eliminate the asphyxial factor. My purpose in using re-breathing was to conserve the nitrous oxide and oxygen on the ground of the cost. I found, however, that a more satisfactory anesthesia, with no alarming symptoms or deleterious results, was obtained by this means.

The respirations of the patient under nitrous oxide and oxygen are greatly increased in both volume and frequency throughout the operation due to the fact that the afferent threshold of the respiratory center is not raised to the extent that it is under ether or chloroform, and the irritation due to traumatic origin is excluded to a much less extent. It is readily seen, therefore, that this excessive pulmonary ventilation may very rapidly take carbon dioxide from the blood. By allowing the patient to rebreathe some of his own carbon dioxide a normal amount of this substance in the blood may be more nearly maintained. With the amount of re-breathing which I employ the concentration of carbon dioxide is from 5 to 9.5 per cent. I arrived at these figures by having the contents of six bags analyzed. These tests were made as follows: Case 1, a large woman, age 51, was anesthetized for an operation which lasted one hour and twenty-four minutes. The proportion of nitrous oxide to oxygen that carried the patient along in profound anesthesia was arrived at fifteen minutes after the anesthesia had been induced. Respirations were from twenty-four to thirty per minute, regular and of good volume. The test bag was attached directly to the face inhaler and was soon filled with the gas that the patient was breathing. The first test was made after the patient had been under the anesthetic twenty-five minutes. The second test was taken after the patient had been under the anesthetic for eighty minutes. No changes were made in the proportion of the nitrous oxide and oxygen being used. I expected to find the exact per cent of carbon dioxide in the bags, but the analysis showed that bag No. 1 contained carbon dioxide 7.4 per cent and bag No. 2 carbon dioxide 5.5 per cent. One hundred and forty gallons of nitrous oxide and twenty-six gallons of oxygen were consumed.

Case 2, a man, age 60, weighing 190 pounds, and having a short thick neck, the operation being a double herniotomy. Some difficulty was experienced in obtaining complete relaxation of the musculature and it was necessary to keep changing the proportions of the nitrous oxide and oxygen more or less for the first twenty-five minutes, after which time no change was made for forty-five minutes. The first test bag was taken thirty minutes, the second sixty minutes after the anesthesia was started. Analysis of bag number 1 showed carbon dioxide 5.125 per cent. Bag number 2 showed carbon dioxide 3.43 per cent. The length of the operation was one hour and ten minutes. One hundred and fifty gallons of nitrous oxide and twenty-eight gallons of oxygen were used. The patient's respirations were from thirty to thirty-eight per minute, being full and regular.

Case 3. The patient was an anaemic, frail woman. The operation was vaginal plastic and laparotomy. The length of the operation was one hour and thirty-eight minutes. The proper proportion of nitrous oxide and oxygen was arrived at in about eight minutes; no change in this proportion was necessary throughout the remainder of the operation. The first bag was taken in twenty minutes and the second in one hour and twenty-five minutes after the anesthetic was started. Bag No. 1 showed carbon dioxide 8.6 per cent, bag No. 2 carbon dioxide 5.25 per cent. The amount of nitrous oxide used was one hundred and eighteen gallons, oxygen twenty-seven gallons. The average respiration was thirty-two per minute, regular but rather shallow. No ether was used in any of these cases.

It is interesting to note the difference in the per cent of carbon dioxide when the proportion of the gas used is not changed, the same amount of re-breathing being thus assured. The small percentage obtained after the patient had been under for some time may have been due to the fact that the normal process of oxidation was being interfered with, showing the influences of shock.

The average patient under nitrous oxide-oxygen will breathe 600 cc. at each inhalation and will inhale about thirty times a minute, making about 270 gallons of gas per hour. By this method of re-breathing which I employ one hundred gallons of nitrous oxide and twenty gallons of oxygen per hour, as a rule, are utilized.

The difference between 270 and 120 is 150, which represents the amount of the gases re-breathed. With this amount of re-breathing there is no danger of carbon dioxide poisoning, nor is there present enough carbon dioxide to lower the tension of nitrous oxide below that necessary to produce surgical anesthesia.

The proper amount of re-breathing of nitrous oxide and oxygen must be governed by the symptoms in each individual case. If too much re-breathing is allowed the patient will show symptoms of light anesthesia, quickly followed by asphyxial manifestations, and an excessive amount of carbon dioxide will be manifested first by rapid forced respiratory efforts, followed by sweating, livid appearance, rapid thready pulse, and finally by cessation of respiration.

UTILIZATION OF POSITIVE INTRA–PULMONARY PRESSURE OF THE CASES

It is known that the blood will absorb forty-five volumes of nitrous oxide to one hundred volumes of blood at atmospheric pressure. I have found that more profound anesthesia resulted when nitrous oxide under positive pressure was administered. This indicated that a greater amount of gas was absorbed or taken up when increased pressure is used. Paul Bert, whose theory is well known, placed his patients in an air-tight chamber and subjected them to increased pressure, this pressure being increased not only within the lungs but without as well. Willie Myer in an article ''Pneumectomy with the aid of differential air pressure'' cites his work in this connection. Bunnell in a recent article reports three cases of intra-thoracic surgery in which he used positive pressure.

In 1907 I began to use positive intra-pulmonary pressure in the administration of nitrous oxide and oxygen for surgical purposes.

My first work of this kind was for Dr. C. B. Parker of Cleveland. The operation consisted in the resection of four or five ribs for extensive empyema involving both lungs. I have administered nitrous oxide and oxygen with positive pressure for intra-thoracic surgery in over forty cases, being able to control accurately the pressure of the gases, and I have never encountered even a temporary cessation of respiration in a single case. I soon noticed that more profound narcosis resulted when positive pressure was used than when it was not used. I have, therefore, utilized this additional factor in all my subsequent work. I have been able to administer nitrous oxide with excellent results in all intra-thoracic surgical cases which have been presented. The lungs could be held in a normal position or could be extended more or less if desirable. The best working pressure, in my experience, is from 4 to 6 mm. Hg, but a much greater pressure, however, may be used without occasioning any alarming symptoms. In patients possessing heavy, powerful, muscular chests a pressure of from 24 to 30 mm. of mercury may be employed to advantage.

That it is a dangerous practice to use positive pressure in anesthetic work is a theoretical objection which is not borne out by the clinical facts. It is essential, however, that the pressure employed be known, a very simple positive pressure valve making this possible.

Utilization of a positive intra-pulmonary pressure in the administration of nitrous oxide is not dangerous; on the contrary, it is an important factor in the production of profound anesthesia. In addition to this it renders possible the safe performance of intra-thoracic surgery.

Some may think it is not necessary to utilize the above principles, but if you do not do so it simply means that an unsatisfactory anesthesia will be the usual result, and a good anesthesia will be the exception. A gas anesthetic may be administered by using only a cylinder of nitrous oxide and a few pieces of gas pipe or a tomato can, but I will leave to your own imagination the excellence of the anesthesia that would be obtained.

The above principles are more or less essential in administering nitrous oxide-oxygen, and in utilizing the same we are able to produce a satisfactory anesthesia in practically every case and under any condition.

ANALGESIA AND HOW IT IS OBTAINED

I do not think there is a more discussed subject in dentistry today than analgesia, and I think it is probably less understood than any other subject. At the same time I am sure it offers a greater opportunity to men of the dental profession than any other subject that has ever been presented, and will result in untold blessings to suffering humanity.

Analgesia is a name given to a condition where the power of appreciating pain is absent while conscious tactile sensibility and all other functions are preserved. Strictly speaking, therefore, true analgesia is rarely met with, but a condition of partial analgesia is easily obtained with a large number of drugs and anesthetic agents when they are administered gradually and in small quantities. Claude Barnard claims that analgesia is brought about when inhaling an anesthetic by the action of the anesthetic on the sensory centers of the cerebro-spinal axis, the sensibility of sensory nerve endings is destroyed, not from the action of the anesthetic upon those endings, but from their action upon the centers themselves. He also expresses a belief that the nerve plays the role of the principle nerve center influencing the secondary nerve centers of the spinal cord, although it is incapable itself of being influenced by the latter.

Gaspre believes that analgesia depends upon the sensory nuclei of the cord or cerebral ganglia being effected by the anesthetic before the cortical centers, so that sensory impressions are blocked on their way to the receptive areas of the cerebrum. Others, however, believe that the block takes place in the cerebral cortex.

It is very fortunate indeed that in 95 per cent of all cases a degree of analgesia can be obtained with nitrous oxide and oxygen which makes it possible to perform practically all operative work on the teeth without any appreciable pain. If any of you have had any experience with analgesia you have undoubtedly noticed that you could obtund sensitive dentin, but the gums and adjacent tissues or an exposed pulp would not be obtunded. This is accounted for by the fact that the presence of nerve fibre in dentinal tubules has never been demonstrated (Mummery), and it is erroneous to state that the sensitiveness of dentin is due to the irritation of nerve fibers there present. The dentinal tubules contain protoplasmic processes which have a direct connection with the odontoblasts, which in turn lie in protoplasmic relations to the nerve endings. The protoplasmic processes within the tubules of the dentin are more easily obtunded than is real nerve tissue. Therefore, more profound analgesia must be obtained if the gums and pulp are to be obtunded, and as a rule this cannot be obtained short of anesthesia.

The stages of analgesia cannot be produced with the same degree of certainty and exactness as the anesthetic stages, for no matter how efficient you may become with analgesia there are a few cases that will be met with where it is impossible to secure complete insensibility of the dentin short of unconsciousness. However, you will find in some of your cases that when you apply an excavator or burr to a cavity you may evoke responses which have all the appearances of, and in one sense are, conscious responses, but owing to the want of synthesis in the sensory impressions received, and to disturbances within the receptive centers themselves, pain is either not appreciated as pain, or if appreciated, is not remembered.

The analgesic symptoms are: A peculiar pleasant feeling of numbness in the extremities which soon encompasses the entire body. The mental condition is usually stimulated so that the patient is in a happy, care-free frame of mind, resembling a pleasant state of intoxication. The mental condition of your patient has a great deal to do with the success of analgesia more than in anesthesia, for the actual work is being done while the patient is conscious, with a disturbance of judgment, control, volition, and excessive ideation. It is necessary to inspire confidence in your patient, and suggesion or moral suasion is a highly important factor in the success of this work. It is not necessary for you to become hypnotists in order to be successful with analgesia, nor can I tell you how to go about gaining the confidence of your patients. The ability to inspire confidence in patients is born in some men to a greater degree than it is in others, but all of us have this ability to a greater or less extent. We also have our individuality in applying it. Success will also depend greatly upon a man's knowledge of human nature, and one line of suggestion to all types of patients would not do at all, so I will leave it to your good judgment just how to apply your suggestions so as to gain the confidence of your patients, but I wish you to remember that when strong mental impressions are produced from any cause results will surely follow.

It is practically impossible for a stranger to the patient to have success in this line of work because of the lack of confidence that would necessarily exist in such instances. You could, therefore, expect far better results in the quietness of your own office where your patients have implicit confidence in you and your ability. Having gained the confidence of your patient, it is a comparatively simple matter to induce a certain degree of analgesia, and the method that I employ is as follows: The inhaler may be held by the patient if he is nervous, and this at times seems to give something to attract the attention, but as a rule the arm and hand will become tired in a few minutes and the patient will be perfectly willing for you to put around his head the band which will hold the inhaler firmly in position. The air valve which is found at the side of the inhaler should be opened; the nitrous oxide should be allowed to flow at the rate of 20 to 25 gallons per hour and the oxygen at the rate of 12 to 15 gallons per hour; the patient should be allowed to breathe this mixture for at least 3 or 4 minutes and in the majority of cases a satisfactory condition of analgesia will have been obtained. If you have a susceptible patient, a condition bordering on the second stage of anesthesia may result. If such a condition should arise, less nitrous oxide should be given, as it is to be borne in mind that analgesia is not anesthesia and the patient should not be carried into the second or third stage of anesthesia unless this should be essential in order to handle the exceptional case. In the non-susceptible cases it will probably be necessary to close the air valve more or less and in some instances a greater amount of nitrous oxide will be necessary in order to produce the desired result. Generally speaking, however, if the nitrous oxide is allowed to flow at the rate of about 20 gallons per hour and the oxygen at the rate of 15 gallons per hour a degree of analgesia will be obtained which will make it possible to perform practically all operations upon the teeth without pain.

In order to take care of the slightest variation which will be found necessary according to the susceptibility or non-susceptibility, this may be controlled by the air valve above referred to, either allowing more or less air as the symptoms may indicate. The greatest trouble that the beginner has with this line of work is from the fact that he uses too much nitrous oxide and carries his patient to the second stage of anesthesia, and does not take sufficient time in producing the analgesic stage. From four to five minutes is the least time which should be consumed in properly bringing about this condition.

From my experience with this anesthetic I can say that there is no danger connected with this form of treatment and the most nervous patient takes it without the least hesitancy. It is understood, of course, that the patients are not to be carried to the unconscious stage at any time, but are to be in control of all their mental faculties at all time.

In regard to the preparation of the patient before analgesia, it is always best not to lay too much stress upon unnecessary preparation, for if you do it will have a tendency to make your patient uneasy, frightened, and nervous; but there are a few things that should be insisted upon. It would not be wise to maintain analgesia for any considerable length of time if the patient has a full stomach. This especially applies to boys from the age of twelve to sixteen, as they have an unusual tendency to become sick. Short analgesia from five to eight minutes may be safely maintained even on a full stomach, but you are very liable indeed to have a sick patient if a longer analgesia is maintained under these conditions. It is just as important to remove tightly fitting collars during analgesia as it is during anesthesia. I never have had a case, however, where I thought it necessary for a patient to remove the corsets. In extremely nervous patients I have found it to be advantageous and a great help to administer by mouth a half hour before starting analgesia one quarter grain of morphine and 1/150 grain scopolamine. You will marvel at the change in the patient, at his different attitude and temperament after he has taken these drugs; instead of being frightened almost to death and all in a tremble and sometimes showing a nasty disposition, the patient will be unafraid, tranquil, and responsive. You will be able to obtain a much more satisfactory analgesia in such a patient than is possible otherwise. In addition to all of this, scopolamine and morphine will produce a certain degree of analgesia and is used with excellent results for this purpose during childbirth. You run no risk of starting a bad drug habit, for it will probably not be necessary to use it again after the first time and the patient should not know what the tablets contain. This treatment is very useful indeed in these exceptional cases before anesthesia for extraction at times. I have in mind a patient who had made four or five trips down town to have her teeth extracted, but she had not the courage to enter the reception room, as her nerve would entirely leave her when she got that far. She would stand around the hall for hours. but could not be persuaded to even come in and sit down. Upon her sixth and last trip she was in the hall three hours and stopped every patient as they left the office to inquire if they were hurt or if the gas was bad to take and innumerable other questions, until she became a nuisance. I finally went out and tried to send her home. She would not go, so I gave her one little tablet of scopolamine and morphine and told her to swallow that with a little water, which she did. We left her in the hall, but within ten minutes she walked into the reception room and was ready to be waited upon. She took her seat in the chair and never made a move and was peacefully asleep in fifteen seconds. She awakened promptly and, although she had eight teeth removed, she declined to lie down for a little while, but insisted on returning home, radiantly happy. This was the result of 1/150 grain scopolamine and 1/4 grain of morphine.

The result in such nervous cases is as striking during analgesia as it is during anesthesia.

When you are inducing analgesia go about it as if you were perfectly familiar with it and had been used to using it all your life. This will create the impression upon the patient that it is your usual procedure when pain is to be avoided, and that you use it with the same confidence you do your burr, excavator or chisel. If you so conduct yourself 90 per cent of success in this work is assured. It is an easy matter to instruct your patient what to do, for he practically needs to do nothing but breathe through his nose. If patients are feeling pain instruct them to breathe deeper, and it may be necessary at the same time for you to partially close the air valve, and a satisfactory condition will usually be brought about in a few seconds. Impress upon your patients the fact that they must not allow themselves to become unconscious and they may easily obviate this at any time by breathing through the mouth. You will find after the first experience that most cases will need no further instructions, as they readily adjust themselves to this form of treatment, and further suggestions will be unnecessary, for they will suggest it themselves.

As to the length of time analgesia may be practically maintained, I consider thirty minutes long enough for any one sitting, and I am sure your patient would not be exhausted or materially shocked. But if a much longer time were occupied there would be a case now and then who would be considerably upset and would not have his usual appetite and in some cases would not feel at all well for a number of days. A patient is not in a natural condition during analgesia, and this cannot be indulged in too often or for too long a time without a certain amount of deleterious results. Just what the bad results of over-use of analgesia would be I am not able to say, but I know that some patients do not experience their usual health for some days after being in the analgesic state for an hour or so. Also I wish to advise the dentists against making a practice of the daily inhalation of the gases themselves, for the nitrous oxide habit has been formed by so doing, resulting in either anaemia or insanity.

Do not make the mistake of telling your patients that they will feel nothing while they are in the analgesic state, for this will not be the truth, as they will feel the drill. You should assure them, however, that there should be no pain produced, or if any it is entirely within their control to eliminate it. Having impressed this fact upon them, you will usually receive material assistance from them in producing and maintaining the desired results. It must be borne in mind that the receptive centers are stimulated during analgesia and that ordinary noises are greatly intensified and remarks made are often misinterpreted by the patient. So one should be extremely careful in regard to what is said either to the patient while in the analgesic state or to others in the room. It is not a time for hilarity, and as the patient is in an intoxicated condition he may have a tendency to become talkative and jovial. You should be firm and impress upon the patient the fact that you are giving him this treatment, not to produce a state of hilarity, but to make it possible for you to do his dental work painlessly and well, and therefore he should keep perfectly quiet and do exactly as you tell him. It is too much to expect to be able to handle all cases successfully, as there is more than a little to be learned in handling your patient to secure the best results in analgesia. But this fact should not discourage you, for if you will devote the same amount of time and study of this subject that you would to becoming efficient in any other line of dentistry your success will be assured.

Most of you are undoubtedly more interested in the proper administration of nitrous oxide in dental surgery than you are in general surgery, so I will go into the detail of this subject pretty thoroughly. I wish you to bear this fact in mind, however, that it requires just as much skill and good judgment to administer nitrous oxide in dental surgery as it does in general surgery; in fact, it is more difficult to administer nitrous oxide for the removal of a large number of teeth or an impacted tooth than it is for the removal of the appendix.

In mouth surgery we have the mouth open and must at the same time prevent the patient from breathing air through it, a pretty difficult feat sometimes. Also we have the blood to contend with, and respiration interfered with to a greater or less extent from one cause or another, such as forcing the chin down too far or pushing the tongue back, etc. In fact, the only other class of operations harder to handle is that for the complete removal of tonsils and adenoids. Reasons for this I will give in another lecture.

We are continuing the administration of nitrous oxide and oxygen until we can complete our operation successfully, the same as the surgeons have been doing. In order that we may all do this safely, however, it is necessary that the subject of anesthesia should be given continued and close attention. It is a lamentable fact that this important subject, the administration of anesthetics, is sadly neglected in many of our medical and dental colleges, and the students are allowed to graduate knowing absolutely nothing concerning general anesthetics and their administration.

Some of our dental schools have better courses of instruction on this subject than have some of the medical colleges. The dental students are not only given a number of lectures but are required to administer some general anesthetic under the supervision of a competent instructor. The average dental student, therefore, is as competent and as well qualified legally to administer general anesthetics as is the average graduate of medicine. More complete instruction along this line, however, in both the dental and the medical schools is an urgent need at this time.

THE LEGAL RIGHTS OF A DENTIST IN ADMINISTERING ANESTHETICS

This question has been asked me a great many times and it may be asked of you. I think it is advisable to tell you just where the dentists stand in regard to this subject. The dentist's right to administer anesthetics in his own practice has very seldom been questioned by educated men, but the right to administer general anesthetics for a physician or surgeon has been questioned by some men and by some medical boards. Wherever this question has been brought to an issue it has been found that the dentists have the legal right to administer general anesthetics, not only in the practice of dentistry, but in surgery as well. The average dental student receives as much instruction along this line as the average medical student (unless the latter has hospital training), and is examined, and if successful is licensed by his state board to practice all phases of his profession. He possesses the technical right to administer anesthetics the same as the physician, but the law does not stop there. It requires that in addition to the scholastic education and preliminary instruction given at his college he must possess and exercise such a degree of skill as is common in similar localities to that in which he is practicing, and, further, he must bring into every case that degree of skill, care, and competence.

The legal right, then, to administer anesthetics necessarily includes experience to such a degree as to enable the dentist to comply with the rule last stated, and if he does possess this degree of skill and has been duly authorized to practice dentistry under the laws of his state and brings that skill into a case, and this can be shown by fellow practitioners, he can not legally be found guilty of malpractice. On the other hand, all the diplomas and licenses he could haul away in a wagon will not prevent a legal verdict against him for malpractice if he does not possess the degree of skill above set forth and, further, bring to the particular case the requisite care and skill such as is possessed by the other doctors, either dentists or physicians, practicing in similar localities.

It is plain to be seen that experience, ability, and proficiency are absolutely essential to protect any doctor from a verdict in a malpractice suit, while they might have no bearing whatever upon his right to practice in a general way and are inquired into by the examining board which issues to him a license only in a way designed to show what his scholastic teaching has been. I wish to draw a strong contrast between the right to practice given by a license and the proficiency which is an additional requirement in a court of law to protect one against an adverse verdict when charged with malpractice.

TECHNIQUE OF ADMINISTRATION

I will now give you the technique for administering nitrous oxide and oxygen for the extraction of a large number of teeth. The patient should be prepared in that he should not have had solid food for at least five or six hours before the anesthetic is administered. If only a few teeth are to be removed this does not apply. The bladder should be empty, otherwise embarassing conditions are sure to arise, unless this matter receives attention. Tight collars and neck bands should be removed. The confidence of the patient should, of course, be gained, the influence beginning as soon as the patient meets the assistant. The patient should take a comfortable position in the chair, the head being held in a straight line with the body, being careful not to put it too far back or too far forward. Either position will tend to obstruct respiration. The nasal inhaler is used in all of these operations unless there is complete nasal obstruction, in which case it will be necessary to use the face inhaler and perform a quick operation, or place the nasal inhaler over the mouth until anesthesia is established, then place it over the nose and you will be able to force a sufficient volume of gas into the mouth to continue the narcosis. You may be aided greatly by the use of the surgical sponge in the mouth. The patient being in the proper position in the chair, the nasal inhaler is adjusted over the nose, the thumbs being used to spread the lower part of the rubber hood in order to prevent the partial obstruction of the nasal passages. The nitrous oxide is allowed to flow at the rate of about 150 gallons per hour. The patient is instructed to take rather long, but not too deep, inhalations; at the same time the oxygen is allowed to flow at the rate of about 15 gallons per hour. The oxygen bag should have been filled before the administration commenced. It will be necessary as a rule to increase the amount of oxygen after the first three or four inhalations to about 20 gallons per hour, as the condition of the patient may indicate. The patient will pass into the anesthetic state in from one to two minutes. The mouth prop is inserted after the adjustment of the inhaler. The mouth being open, the patient is instructed to breathe through the nose, relax and go to sleep. If mouth breathing is noticed and persisted in after being told to breathe properly, place at once a rubber over the mouth which will compel proper breathing, carrying the patient to the required depth of anesthesia, then remove the rubber from the mouth. Should the patient commence to breathe through the mouth, the exhalation valve of the inhaler should be closed and the nitrous oxide and oxygen forced rapidly, the inhaler held firmly over the nose and the gases forced through the nasal passages under sufficient pressure to exclude the atmospheric air. The patient is then compelled to receive the gases into the lungs even though he is inhaling and exhaling through the mouth. This is known as pharyngeal insufflation anesthesia. Less oxygen may be necessary under these circumstances than would be the case if the patient breathed continually through the nose, for a certain amount of atmospheric air gains entrance.

The mouth breathing can be controlled to a certain extent by using surgical sponges. These sponges are used for taking care of the blood, and one or more may be packed in the back of the mouth, thus compelling nasal breathing to a certain extent. I have found these to be a great help for work of this kind. They also serve another purpose which is of great advantage and safety, that is, they prevent the flow of blood into the throat, and also prevent the accidental entrance of a tooth into the throat. A few such accidents have been reported with very serious results.

By continually forcing the nitrous oxide, and controlling asphyxial manifestations by the oxygen, the patient can be successfully kept under the anesthetic as long as may be required to accomplish the work well. If the patient continues to breathe through the nose, and not through the mouth, it will not be necessary to allow the nitrous oxide to flow faster than about 150 gallons per hour and the oxygen about 20 to 25 gallons per hour. In the majority of cases this will carry the patient along in a quiet anesthesia. Unfortunately, however, there are cases met with when one's resources are taxed to the utmost in order to anesthetize them successfully. You will have patients perhaps who have an extremely nervous temperament, who are frightened almost to death, for it is a peculiar fact that the average patients are much more frightened when they sit down in the dental chair to have a tooth extracted than they are when they come to the operating room for an operation. They have not had the preliminary preparation that they receive before an operation and they are therefore in a higher state of nervous tension. Also the alcoholic, the strong vigorous man, the excessive smoker, are one and all attempted with nitrous oxide and oxygen anesthesia in the dental practice. It is out of the question to expect to obtain a quiet, profound anesthesia in such cases, for, as I will explain fully later, it is necessary to dull the keener mental perceptions by the administration of a preliminary narcotic such as pantopon or morphine before a quiet and profound anesthesia may be obtained. However, these cases may be anesthetized successfully to allow all dental extractions to be done painlessly without preliminary narcotics, if attention is paid to every detail and sufficient time is taken to put them well under. All atmospheric air must be eliminated and a rather small amount of oxygen used at first, just enough to prevent asphyxial spasms of the muscles, etc. It is impossible to induce anesthesia in these cases if the patient is kept in a pink condition, for more or less cyanosis is essential during the induction, but as a rule this may be cleared up to a considerable extent as anesthesia progresses. It is not unusual to consume from three to five minutes in putting such cases under. Mouth breathing must be guarded against, not only during the induction but also during the work within the mouth. Sponges may be used with excellent results for this, but care must be taken that they are not packed too far back, for in that case you would shut off the opening into the nostrils and your patient could not receive the gases and you would cause complete obstruction to breathing as well. It is necessary to have an assistant, trained in this work to help, for it is out of the question for a man to expect to administer the anesthetic and do the operating work at the same time. Analgesia may be controlled without an assistant, but not anesthesia. The nasal inhaler should be held so that perfect coaptation is assured at all times, and the assistant may control the proportion of the gases as they are indicated, following the instructions of the operator. This instruction may be given without saying a word by simply having signals which are understood. A very simple method I use is as follows: When more oxygen is wanted I straighten out my thumb; when less oxygen is wanted I bend my thumb; when a gradual increase in the nitrous oxide is wanted I hold out the first finger until the amount is reached that is wanted; when less nitrous oxide is wanted I close the first finger and keep it closed until the proper amount is being given; if you want the nitrous oxide forced, close the whole hand. After a little practice it will not be necessary for a single word to be spoken to the assistant. It is essentially desirable that the patients should not hear you give any instructions to your assistant, for they would not have the confidence that they otherwise would, and they would have an idea that you are not perfectly familiar with everything, and some of them would think the assistant was administering the anesthetic. They would resent this in some instances. No word should be spoken during the induction of anesthesia, only that directed to the patient, and the only person to talk at this time should be the operator; just what you should say depends upon the temperament of the patient, but all are anxious at this time for encouragement and assurance. Tell them to breathe naturally, but not too deep, relax and try to take a nap. Assure them it is not unpleasant or dangerous and that they will feel nothing. Assure them that you will watch them closely and that everything will be all right. Your patient will probably be unconscious within fifteen seconds, so you do not have to keep this up very long. If they resist any, be firm with them and impress upon them the fact that they are only adding to their own discomfort. Do not force any adults to take the anesthetic if they will not do as you tell them. It is a far better policy to dismiss them. Tell them you will gladly administer the anesthetic to them when they have made up their minds to come in and do as you say. They will return at some later time and give you no trouble. The law in most of the states is very strict in this matter and you dare not hold an adult patient and force him to take the anesthetic. However, if adults are under the anesthetic to the extent that they have not the control of their mental faculties and then resist, you are then at liberty to hold and put them under. Children that have been brought by their parents or guardians may be forcibly held, but not adults in sound mind. It is always best to have friends of the patient out of the room when administering an anesthetic, for they can not help out any and can hinder a lot. Often they require more assurance and attention than the patient himself, and it is not fair to the patient to have one's attention diverted from them and the work in hand. Also you will have, as a rule, a perfectly satisfied patient, but a horrified friend, who will be as loud in his explanation of the awfulness of it all as the patient will be in his appreciation of it. Therefore, the moral is: Keep the friends out if you don't want to have a "knocker." A friend may be present until the anesthetic is started, but should be told beforehand that he should step out of the room when told to do so.

THE ADMINISTRATION OF NITROUS OXIDE AND OXYGEN IN MAJOR AND MINOR SURGERY

I will review briefly the principles involved in the scientific administration of nitrous oxide and oxygen.

First, the administration of pre-anesthetic narcotic when the gas is used as the anesthetic in major surgery, but not in minor or dental surgery. My preference of the narcotics for this purpose is pantopon and atropine. Second, the advantage of oxygen over the atmospheric air because of the small percentage of pure oxygen in the air. Third, the necessity of accuracy in dosage, which is made possible by positive, definite, and even flow of the gases. This will produce an even and safe anesthetic, which is void of intercurrent asphyxia and nausea. Fourth, the advantage of administering gases warm, because they are more readily absorbed and all refrigerant effects with resultant irritation removed, resulting in quicker induction, more profound anesthesia, and a conservation of the body heat. Fifth, the re-breathing of the gases because of the great saving in the amount of the gases used, and the conservation of the normal amount of carbon dioxide in the system during the anesthesia, thus preventing a certain amount of shock. Sixth, the advantage of utilizing intrapulmonary pressure of the gases, thereby causing a greater absorption of the gases, preventing dilution by leakage of air, making it possible to perform the intrathoracic surgery without the aid of expensive differential air-chamber apparatus, etc.

Having thus briefly reviewed the scientific principles involved in the administration of nitrous oxide, I will now point to some of the advantages of gas anesthesia.

When properly administered nitrous oxide-oxygen anesthesia is the safest known, because it does not cause irritation to or decomposition of any tissues or elements of the body. Lung complications are never met with, and I have administered the anesthetic to three patients during an acute attack of pneumonia without in any way making the patient's condition worse; on the contrary, the condition of all the patients improved markedly almost immediately following the anesthesia. Warm gases and non-asphyxial narcotics were responsible for this, I believe. The anesthetic was not administered as a treatment in these cases, but was administered because it was essential to operate in order that the patients' lives might be saved, one a case of acute appendicitis and the two others of strangulated hernia. All three cases got well. I also have administered this anesthesia during a severe attack of diphtheria to a young man that was so unfortunate as to have, at the same time, acute appendicitis. This case made an uneventful recovery. I have administered gas anesthesia many, many times to old people suffering with practically all the complications associated with their age, such as arteriosclerosis, nephritis, diabetes, myocarditis, high blood pressure, etc. I have not seen post-operative suppression of urine in any case, no deleterious effects followed the administration to diabetics in a single case; no complications have ever followed its administration to patients with an abnormally high blood pressure, hard arteries, and diseased heart. In fact, the worst surgical risk seems to tolerate the nitrous oxide plus lots of oxygen better than the strong and vigorous.

The safety of nitrous oxide anesthesia depends almost wholly upon the man administering it, for the dangers are technical only, and the extent of controllability depends upon the efficiency obtained by the administrator. Some say flying in an aeroplane is perfectly safe, but you will all agree that this depends mostly upon the efficiency of the man who holds the levers.

Before explaining the technique of administering nitrous oxide and oxygen, I will explain the apparatus to a certain extent so that you will be able to understand my method of administration.

It is essentially desirable to get the gases under perfect control so that it will be possible to know always the exact amount of the respective gases one is giving. This I have accomplished by working out controlling valves whereby respective amounts of gas flowing are known. This has been made possible by using from a supply of known pressure. Having a constant and definite known pressure to use from, it is possible to know just how many gallons per hour of both gases are flowing at any time. This fact makes it comparatively easy to explain and learn the method of their administration. The gases, of course, are warm, so that the patient receives them at a temperature from 85° to 90° Fahrenheit. There is a positive pressure valve on the face inhaler whereby the pressure under which the patient is breathing can be regulated from no pressure to 20 mm. of mercury or higher, as may be desired.

There is no valve between the nitrous oxide bag and the face inhaler, so re-breathing of the gases may be had. The exhalations of the patient, however, do not enter the nitrous oxide bag because there is a constant stream of fresh gas entering it, and the channels throughout the apparatus and tube to the inhaler must empty themselves into the bag before the exhalations would enter. This would not be possible with the method and amount of re-breathing I employ. The average amount of exhalations being from 500 to 600 c.c., part of this amount escapes through the exhalation valve, and only part of the exhaled gases pass into the tube. Numerous cultures been ~~have~~ taken from the inside of the tube and bag, but nothing was found below the upper third of the tube; hence the only parts that it is necessary to sterilize after using are the inhaler and the tube.

I will now endeavor to explain the technique I use in administering nitrous oxide and oxygen in major surgery.

The patient is put on the table where the operation is to be performed and must not be moved to any extent after the anesthetic is started. The administrator should be kind, gentle, but firm, allowing no noise or talking. The only words spoken should be by the anesthetist to the patient. The supply of nitrous oxide and oxygen should be sufficient and at the proper pressure. The nitrous oxide should remain at 25 pounds, the oxygen at 15 pounds pressure from the supply. Open the valves in one of the nitrous oxide cylinders five or six complete turns, open one of the oxygen valves in the cylinder one or two turns. Be sure that the oxygen bag is completely full before starting, otherwise the patient would become asphyxiated before the tension of the oxygen in this bag would be sufficient to force it out. If the oxygen is flowing into the bag at the rate of only about 20 gallons per hour, it would take about five minutes for this bag to fill, so you can readily see the necessity for filling this bag before starting the anesthetic. There is a check valve in the oxygen bag which prevents any contamination of the gas in this bag and it requires some pressure to raise the valve, so the patient will not receive any oxygen unless this bag is full, if the valve from the nitrous oxide bag is open at the same time. Having the gas supply pressure properly regulated and the oxygen bag full, you now open fully the valves from the bags, place the inhaler firmly in position, being sure you have perfect coaptation. Now open the nitrous oxide controlling valve to 150 gallons per hour and the oxygen controlling valve to 15 gallons per hour and instruct the patient to breathe naturally, relax and go to sleep. After about four or five inhalations advance the oxygen to 30 gallons per hour and about this time move down the collar on the spiral spring to 4 or 6 mm. of mercury pressure. Now simply keep a clear airway and your patient will pass usually into profound anesthesia in about two or three minutes. As anesthesia progresses you may need to come down on your nitrous oxide to 120 and up on the oxygen to 25 or a little more. These amounts will usually carry the patient along in profound anesthesia during the operation. At its completion, after the peritoneum has been closed (if it has been an abdominal operation), the amount of nitrous oxide can be further reduced, but the oxygen should remain about 25 gallons per hour or more. When all is finished, stop the nitrous oxide flowing and close the valve from the nitrous oxide bag, turn the oxygen controlling valve over to 100 gallons per hour and allow the patient to breathe pure oxygen for about one minute. If no complications have been encountered during the administration, the above technique will be found sufficient in the great majority of cases, but unfortunately some patients do not tolerate any drug or anesthetic well, and some may have a tendency to vomit during the course of anesthesia. If this condition arises it always indicates a comparatively light anesthesia. and you would handle the condition by increasing both the nitrous oxide and oxygen and deepen the narcosis. A large per cent of oxygen would be required until rhythmic breathing had been re-established, on account of the fact that the patient is not receiving a free interchange of the gases in the lungs, due to the obstruction caused by the efforts to vomit. Therefore, as soon as free breathing is again established less oxygen will be required, which will allow you to go back to the amount that was sufficient before retching commenced.

If the patient's airway becomes obstructed from any cause, this obstruction must be removed, for good anesthesia cannot be obtained or maintained unless there is a clear airway all the time.

I have been using a modification of Hewitt's artificial airway to obviate this trouble for some time. This artificial airway consists of a hollow brass tube so shaped that it passes back of the tongue and as far down as the epiglottis. This tube is not put in place until profound anesthesia has been established and there are some indications for its use.

There are a number of patients with whom it is impossible to get complete relaxation, for instance, in cases of alcoholics, drug fiends, patients under high nervous tension, and in certain abdominal operations where masstraction is made in the removal of large tumors. In such cases, if a sufficient depth of anesthesia cannot be obtained when using 160 gallons of nitrous oxide and 25 to 30 gallons of oxygen, it is much better and safer to use a little less nitrous oxide and enough oxygen to keep a good pink color and add a sufficient percentage of ether to obtain the desired amount of relaxation. Usually 6 to 8 per cent of ether is sufficient, but at times a much greater per cent is necessary. However, after complete relaxation has been obtained the ether can usually be discontinued and the operation finished satisfactorily with the nitrous oxide and oxygen alone.

As to the length of time a patient can be held safely under nitrous oxide and oxygen it cannot be definitely stated, but this we know, that when a non-asphyxial form of nitrous oxide anesthesia is obtained it can be prolonged to a much greater extent than is possible with ether, chloroform or any other of the cell-solvent anesthetic agents. The longest time I have held a patient under nitrous oxide and oxygen is four hours and eight minutes. The patient was a woman 65 years of age, and the operation consisted in the removal of the left breast and muscles to the intercostals and the removal of carcinomatous glands in the axilla. The patient regained consciousness within sixty seconds after the nitrous oxide was discontinued and was in excellent physical condition, having a pulse of 84 and of excellent quality. She made an uneventful recovery from this operation, but died some months later from a recurrence of the cancer.

My time will not permit of a full discussion of the methods used in administering nitrous oxide and oxygen for all classes of operations, but I wish, however, briefly to explain how best to administer it in certain operations where difficulty is usually experienced in applying the anesthetic. For operations not about the head and neck there is usually no interference with properly administering the gas, because the face inhaler may be used as above explained and all atmospheric air excluded. However, for all the following operations it is necessary to employ a somewhat different technique, inasmuch as the mouth or nose of the patient must not be obstructed. In cleft palate and hair-lip operations the face inhaler is employed until complete surgical anesthesia is induced; the gases are then forced through the tubing, on the end of which is attached a mouth tube which, when placed in the mouth of the patient, conveys the gases into the pharynx. If any difficulty is experienced in maintaining sufficient depth of anesthesia the gases are allowed to pass over the ether to take up any amount thereof that may be necessary to control the patient properly. Usually the ether may be dispensed with after the first ten or fifteen minutes. The administration of the anesthetic in this manner leaves the field of operation unobstructed and permits the maintenance of an even narcosis.

For the removal of tonsils and adenoids the technique of administering nitrous oxide and oxygen is more difficult than in any other class of operations, for the reason that the patient's mouth must be kept open and that, it being open, he naturally breathes through it. The throat reflexes are among the last to be abolished; the respirations are apt to be interfered with by the accumulation of blood and mucous and by the jaw being open too far or by the manipulations of the operating surgeon. Nevertheless, nitrous oxide and oxygen may be administered in 95 per cent of these cases, and by supplementing nitrous oxide with ether, all such cases can be successfully handled and a continued uninterrupted narcosis maintained until the completion of the operation without regard to the length of time consumed. The nasal inhaler is adjusted over the patient's nose and held in place by the elastic band passing around the head, but it is also necessary to hold the inhaler firmly with one hand. The patient is compelled to breathe through the nose, the mouth being held closed until anesthesia has been established. It is usually necessary to take from three to five minutes to establish anesthesia. When profound anesthesia is obtained the exhaling valve on the nasal inhaler should be closed so as to make a tightly fitting cap over the patient's nose. The mouth tube is placed in the corner of the patient's mouth at this time and the gases are allowed to pass through both the nasal inhaler and the mouth tube. The mouth gag is inserted at this time, the patient will now breathe through the mouth, and it therefore becomes necessary to allow the gases to flow a great deal more forcibly than they did during the induction of anesthesia. Sufficient volume of the gases may usually be forced through the mouth and throat of the patient to maintain the narcosis indefinitely. There are a few cases, in adults especially, where it is impossible to maintain a deep anesthesia with this method. It is then advisable to allow the gases to flow over the ether in order to take up any percentage that may be necessary to control the patient. It is always to be remembered when using ether with nitrous oxide that oxygen should be used in sufficient amount to entirely prevent cyanosis or congestion.

For the excision of the tongue or any other major operation within the mouth where troublesome hemorrhages are apt to be met with, nitrous oxide and oxygen are administered as follows:

Anesthesia is induced by means of the face inhaler, probably being necessary to use a small amount of ether with the nitrous oxide and oxygen in order to induce a sufficient depth of anesthesia to hold the patient while the intranasal tubes are put in position. These intranasal tubes are soft rubber catheters connected with a special exhaling valve. When the facial inhaler is removed, the intranasal tubes are inserted through the nose, passing into the larynx as far as the epiglottis; the tongue is then drawn slightly forward, the throat packed firmly with gauze dampened with normal saline. This packing should be done in such a way as to make it impossible for the air to pass around it or for the blood or mucous to enter the throat. The patient now breathes naturally, the inhalations pasing through the tube and out through the exhalation valve. Nitrous oxide may now be applied without interference with the proper performance of the operation, and since there can be no obstruction of respiration a profound and tranquil anesthesia may be as easily maintained as when the face inhaler is employed.

A great deal of difficulty is experienced in administering this anesthetic for the excision of the larynx. Usually when these cases are presented for operation a tracheotomy has previously been performed and the patient found to be wearing a tracheotomy tube. Breathing is mostly through this tube. All patients I have had, with one exception, have breathed a little also through the nose. My technique for administering nitrous oxide-oxygen for this class of cases is as follows: There are two outlets for the gases on my apparatus, through either or both of which the gases may be directed. The tubing from one of these outlets is attached to the face inhaler, and the tubing from the other outlet is attached to a specially constructed positive pressure exhalation valve, and to this valve is attached an intratracheal tube.

The facial inhaler is placed over the face of the patient and the intratracheal tube is placed at the end of the tracheotomy tube; the gases are allowed to flow through both the face inhaler and the intra-tracheal tube. It is usually advisable to use a small percentage of ether with nitrous oxide and oxygen in order that profound narcosis may be established. When this has been done the tracheotomy tube is removed and the trachea is cocainized. The opening in the trachea should be made large enough for the insertion of the intratracheal tubes which will entirely fill the trachea. The gases, being now cut off from the face inhaler, will pass into the intratracheal tube. The intratracheal tube should pass into the trachea nearly to its bifurcation and may be stitched to the skin to insure against its displacement. By using a tube that entirely fills the trachea the patient will inhale and exhale entirely through the tube. This makes it possible to use positive pressure of gases. It also obviates any possibility of blood or mucous entering the trachea.

CLINICAL EXPERIENCE

Laboratory experimentation amounts to little unless its results are borne out in practical clinical experience. Quite as much may be learned from clinical observation and experience as from laboratory research, provided the same accurate, painstaking methods be employed. It may not be amiss, therefore, in this connection to review briefly personal experiences with nitrous oxide-oxygen employed with the principles I have given.

During the past twelve years I have been advocating the many advantages of nitrous oxide and oxygen as a general anesthetic for use in both dental and major surgery. I have administered gas-oxygen anesthesia to patients of all types and ages for practically every conceivable operation, lasting from a few minutes to four hours and eight minutes. I will not attempt to enumerate or classify the different operations, for the list covers practically every operation that is being done today from the most extensive laparotomy to the more simple operations, such as the removal of tuberculous glands, etc. It may be stated, however, that there is no operation performed at the present time in which nitrous oxide-oxygen or nitrous oxide-oxygen with ether cannot be employed. From May, 1904, to January 1, 1914, I have administered nitrous oxide-oxygen as the anesthetic for general surgical cases 11,872 times. All but 25 per cent of the cases were given the pure nitrous oxide-oxygen and to this 25 per cent a small amount of ether was given with the nitrous oxide-oxygen. In addition to this number, I have administered nitrous oxide-oxygen by means of continued nasal method for dental operations, lasting from a few minutes to forty minutes, 17,164 times. In all of these administrations, amounting to 29,036, there has been but one fatality during the course of anesthesia. I reported this case in detail in a paper read in the Section of Stomatology of the American Medical Association in 1909. This was, not strictly speaking, an anesthetic death. I am aware, however, that at least eighteen fatalities have occurred during administration of nitrous oxide-oxygen, but in a large percentage of these cases, however, the patients were also receiving some ether. From this it will be seen that gas-oxygen anesthesia is not without its limitations and dangers.

LIMITATIONS OF NITROUS OXIDE-OXYGEN

In discussing the specific limitations of nitrous oxide-oxygen I wish to emphasize the fact that the subject is discussed in a broad sense, keeping in mind the possibilities of the administration of this anesthetic by persons not especially skilled in this form of anesthesia using only nitrous oxide-oxygen and not supplementing it with ether.

The limitations of nitrous oxide-oxygen differ greatly in the hands of the expert, and to the average anesthetist probably the greatest limitations of this agent is the difficulty experienced on the part of the anesthetist in mastering and executing the fundamental principles involved. In the hands of other than an expert, I consider nitrous oxide-oxygen to be contra-indicated for any operation in children under five years of age. The reasons for this are that young children are easily asphyxiated; that they are easily thrown into epileptiform twitching of the body; and that they pass from light to profound anesthesia in a remarkably short time. It is, therefore, very difficult to administer nitrous oxide and oxygen to young children successfully. This agent is also contra-indicated in old people in whom the degenerative process of the body is manifested, especially when an extensive degree of arteriosclerosis is present. The reason for excluding this class of cases is the likelihood of a certain amount of asphyxia accompanying the anesthesia. In the aged, however, if a non-asphyxial form of anesthesia can be secured throughout, nitrous oxide and oxygen is without question the best anesthetic to be employed. Some of my most gratifying cases have been old people and I have had no bad results with this class of patients. I have always maintained a non-asphyxial narcosis, not hesitating to use ether if necessary.

If a major surgical operation is to be performed, it would be very unwise to attempt to anesthetize with nitrous oxide and oxygen a strong, vigorous, rough man whose habits include an excessive use of tobacco and liquor, unless the anesthetist had become thoroughly proficient in the handling of this anesthetic agent. Unless the desired depth of anesthesia can be obtained in a given case without a marked degree of asphyxia it is much safer to use more oxygen, a little less nitrous oxide, and to add enough ether to secure the desired amount of relaxation. This applies entirely to major surgical operations. A slight degree of cyanosis is not objectionable nor is it dangerous, and if less than 11 per cent of oxygen be used with nitrous oxide more or less cyanosis will be manifested. A slight degree of cyanosis is the rule with this form of anesthesia unless a large dose of pre-anesthetic narcotic is first given or some ether is administered with the gas. The percentage of ether given with the gases should be known as far as this is possible.

The ideal patients for nitrous oxide-oxygen anesthesia are the very ill, the anaemic, the debilitated, those possessing low vitality from any cause, in short, all except those requiring a powerful anesthetic agent. The great majority of cases may be handled safely and successfully if the nitrous oxide and oxygen be administered by one skilled in its administration.

SPECIAL PHYSIOLOGY OF NITROUS OXIDE

In taking up the subject of special physiology of nitrous oxide anesthesia I wish to state that there is very little known in regard to the action of nitrous oxide upon the blood, nerve cells, or any other elements of the body.

There have been quite a large number of men who have done more or less original research along this line, but their combined efforts have not added much knowledge to this important subject. I will give you the facts as far as they are known and express my belief on the subject founding my belief from the experience gained in my wide clinical experience with nitrous oxide as a general anesthetic.

Entrance into the Organism.—Nitrous oxide enters in the organism by absorption, and the most convenient channel for the introduction of the gas into the general circulation is that presented by the respiratory passage, the large area furnished by the pulmonary alveoli and capillary network being particularly favorable to rapid absorption. The more powerful anesthetic agents, such as chloroform and ether, may be and are sometimes introduced into the organism by the intravenous route, and per rectum. The agents introduced in this manner have not proven satisfactory and as a rule are irregular and uncertain owing to the rapid elimination of these volatile substances by the lungs. Intravenous anesthesia with ether has some advantages, but the disadvantages outweigh the advantages. Rectal anesthesia has some application when for some reason ether could not be safely administered through the lungs, but if nitrous oxide and oxygen were available there can never be any advantage in this method.

The usual method consists of forcing a stream of ether vapor into the colon, but usually much irritation is produced and an unsatisfactory anesthesia obtained.

It was my pleasure this summer to see the first work ever done with oil-ether anesthesia per rectum. Dr. James T. Gwathmey of New York has been working along this line, and after a good deal of animal experimentation used the method on human subjects. He reported his results before the anesthetic section of the International Medical Congress which was held in London last August. His method consists of placing oil and ether into the colon by inserting a catheter through the rectum and allowing this mixture to enter slowly. He found that carron-oil was the best to use, as it separated from the ether more readily than other oils. He recommended a solution of from 65 to 70 per cent ether, and owing to the rapid elimination of ether through the lungs he advocated holding a paper bag over the face of the patient and allowing the patient to re-breathe into this bag.

The cases that I saw were perfectly anesthetized and entirely satisfactory. Recovery took place without any annoyance whatever and there was no vomiting or nausea.

As far as I know, I was the first to use this method in connection with nitrous oxide and oxygen. There is a certain percentage of cases in major surgery when sufficient relaxation cannot be obtained with nitrous oxide and oxygen alone, and it is necessary to use some other anesthetic in connection. Ether is without doubt the safest and best agent to use with nitrous oxide in these cases, so I have used Gwathmey's colonic method in a few cases with the most excellent result. A comparatively small amount of ether was used, about 3 ounces, but by preventing to a considerable extent the elmination of the ether through the lungs by allowing a large amount of re-breathing of the nitrous oxide and oxygen I had profound anesthesia with complete relaxation, and less than the average amount of nitrous oxide and oxygen was used.

I will not dwell further upon these methods, but will trace the entrance into the system of nitrous oxide through the lungs.

Upon entering the lungs the gas passes from the pulmonary alveoli into the blood and from the blood to the lymph. For this to take place it is necessary that the pressure of the anesthetic must be higher in the alveolar air than in the blood and higher in the blood than in the lymph. In addition, if the percentage of anesthetic in the inspired air be kept constant the pressure corresponding to this percentage must be higher than in the expired air, which again must be higher than that in the alveolar air. The blood will continue to absorb the N_2O until an equilibrium is established between alveolar and blood tensions.

The amount of absorption will be greatest at the beginning of anesthesia and will be diminished with the ascent of narcosis. The rate of absorption of nitrous oxide by the blood is affected by numerous factors, however, such as the difference of the pressure of the anesthetic in the blood and in the alveolar air, and the rate of the blood stream through the lungs and the rate and depth of respiration. In the early stages of anesthesia, when the vapor pressure in the blood is low, the rate of absorption will be most rapid, and as a consequence, if the percentage in the inspired air be kept at a constant, the difference of anesthetic concentration between the inspired and expired air will be greater than in the later stages of anesthesia. Therefore, if the percentage in the inspired air be kept at the same level the concentration in the expired air will be constantly rising and therefore also rising in the alveolar air, in the blood, and in the lymph. The conclusion is obvious that a safe percentage to administer early in anesthesia is not necessarily safe in the latter stages; in fact, a safe percentage early in anesthesia may be a fatal percentage in the latter stages.

Waller has shown that in the case of a cat a 2 per cent vapor of chloroform was placed as a concentration for the induction of anesthesia, but from a number of observations it is fatal if continued for about two hours.

Another factor which influences the rate of absorption of the anesthetic is the rate of the blood stream through the lungs. It is clear that the slower the blood stream the less anesthetic will be absorbed, for there will be a deficiency of the supply of fresh blood; but, although less will be absorbed, yet the blood will contain a greater concentration of anesthetic when it leaves the lungs, for it will have a longer exposure to the anesthetic in the alveolar air.

We will now consider another important factor which influences the absorption of the gas—the frequency and depth of respiration. It is sufficiently obvious that increased frequency or depth of respiration will raise the percentage of anesthetic in the expired and alveolar air more rapidly than would be the case with unaltered respiration. From such consideration it has been argued that it is actually an advantage to give a higher concentration of anesthetic when breathing becomes most shallow, but one must proceed very cautiously along such lines, for we must remember that feeble respiration or respiratory movement may be due to an overdose of the anesthetic. The rate of respiration must be regarded as the most important factor in the absorption of an anesthetic; it may well become a dangerous one if the respiration increases in rapidity and at the same time increases in volume.

For a quick absorption of the gas we must have an unobstructed airway and rhythmic breathing.

When we have a clear airway and rhythmic breathing anesthesia takes place rapidly. After anesthetic tension of the gas in the blood has been established and the proper proportion of nitrous oxide and oxygen determined, this need not be altered to any great extent unless something arises that obstructs the air passages, such as attempts at vomiting, obstruction caused by pharyngeal and laryngeal spasms, the tongue dropping back, etc. In such events the patient soon becomes cyanotic, notwithstanding the fact that the same amount of oxygen is flowing as previously; the obstruction prevents the patient from receiving it. In this event the oxygen per cent should be largely increased until the cyanosis clears up and the obstruction removed; then the per cent of oxygen should be reduced to the amount which was sufficient before the obstruction took place.

Just how nitrous oxide is taken up by the blood is not definitely known as yet, but it is probably simply carried in solution by the plasma, although it may be possible that there is a slight dissociable combination formed with the haematin and other structures within the blood.

I take my belief in the theory of simple absorption in the plasma from the fact that I can induce more profound anesthesia when using increased pressure of the gas than when not using it. If there was a chemical combination formed between the nitrous oxide and the elements of the blood the increased pressure would have no effect in the number of molecules of the gas taken up by the blood.

Davy's experiments prove that nitrous oxide has the power of turning out oxygen or air from water, and it is probably that in addition to its preventing the access of fresh oxygen to venous blood, it actually dislodges more or less completely that oxygen which still remains in it when it reaches the pulmonary capillaries. As stated before, it is possible that nitrous oxide forms a dissociable compound with haemoglobin and that it may form a similar compound with the protein of the plasma in the same manner as carbon dioxide does according to Boyle. In any event, we know that nitrous oxide is readily taken up by the blood. Paul Burt claimed that one hundred volumes of blood at body temperature will absorb forty-five volumes of nitrous oxide. Herman found that one hundred volumes of blood will absorb somewhat less than sixty volumes of nitrous oxide, but Burt's figures are probably more nearly correct.

When nitrous oxide is absorbed and carried throughout the system it produces a specific or anesthetic effect by its action upon the nervous system. The most highly evolved parts of the central nervous system are first affected. The cerebral cortex usually seems to be affected before any other part of the central nervous system. In all probability the basal ganglia and cerebellum are next involved; the sensory tracts, the centers of the cord which connect the brain with the periphery seem next to share in the process; the cerebro-spinal motor tracts and centers are influenced, finally the respiratory, vasomotor cardiac centers cease to act and death ensues. We cannot speak with precision on these points, for it must be remembered that variations are displayed by apparently similar subjects. Although the sensory nervous system is primarily and fundamentally affected by anesthetics, the motor functions are profoundly modified. Also in the early stages of anesthesia the centers capable of executing complex and co-ordinated movements are first affected, followed by paralysis of the centers governing simple muscular acts, and finally the automatic motor centers of respiration and circulation become involved.

Just what changes take place within the central nervous system which are capable of bringing about a state of anesthesia with nitrous oxide is not definitely known. There have been theories advanced, but I believe that general anesthesia is brought about by some change of a psycho-mechanical character within the protoplasm of the nerve cells, which temporarily interferes with the performance of their normal functions. Whether this change is due to the local effects of the anesthetic itself upon the cell contents or whether some alteration in the blood produced by the anesthetic is the immediate cause of this change I am not able to say. Hewitt says: "There are many remarkable analogies between the effect of simple anoxemia and those produced by general anesthetics, and it is not at all improbable that the future experimental research may lead to the conclusion that general anesthetics produce their characteristic effect by limiting the normal processes of oxidation upon the intellectual, sensory, and motor centers for the execution of their respective functions. There is no doubt that diminished oxidation plays an important part, if not an essential part, in the production of general anesthesia.''

Whatever the physiological action of nitrous oxide may be, it possesses anesthetic properties of its own, and the asphyxial phenomenon which characterizes the action of this gas when administered free from air or oxygen is undoubtedly accidental and dependent upon the crude system of administration. It is true that a slight degree of cyanosis is essential in procuring profound surgical anesthesia with nitrous oxide. I do not believe, however, that anesthesia is caused by asphyxia, because anesthesia still results when nitrous oxide is administered with as much free oxygen as is present in the atmospheric air. It has some other specific effect which at present is unknown, otherwise we should be able to attain as good results by using nitrogen as we do by using nitrous oxide, which we know is impossible.

Hewitt says: ''It is quite conceivable that the effect of nitrous oxide, ether, and chloroform when administered with a sufficiency of oxygen to avoid obvious asphyxial symptoms may be the same, and that this action may be of the nature of de-oxidation. The initial sensations under nitrous oxide are of an agreeable and stimulating character, almost identical with those of ether and chloroform, and when non-asphyxial and deep nitrous oxide anesthesia is established this anesthetic is similar in its main features to that produced by other anesthetics. Were nitrous oxide anesthesia the result of simple oxygen deprivation we should not expect the initial sensation produced by the inhalation of these to be of an exhilarating character. Nitrous oxide has, in fact, quite as good a claim as chloroform to be considered a good anesthetic. It is true that as the former is gaseous at ordinary temperature and normal pressure, it may be administered in its pure state, whle the latter, being liquid, needs vaporization. It is also true that the toxicity of nitrous oxide is of a lower order than that of chloroform; both anesthetics, however, require dilution with air or oxygen in order that the anesthesia of each may become satisfactorily established, and this anesthesia may be readily intensified by reducing the air or oxygen supply.''

NITROUS OXIDE FACTOR IN SHOCK

It is a well-known clinical fact that there is far less shock produced to the patient when the patient is under nitrous oxide and oxygen than there is under any other general anesthetics. In nitrous oxide anesthesia we have to a greater extent a lighter condition of anesthesia than we have when ether or chloroform is the agent employed, as these latter agents dissolve the lipoids of the brain and unfortunately dissolve many other important lipoids in the vital important structures, such as the lecithin in the red corpuscles, the specialized fats in the liver, kidney and other organs. The nerve cells under such conditions are greatly handicapped in performing their normal functions.

Although the afferent impulses reach the brain more readily under nitrous oxide-oxygen than they do under ether, there is much less shock produced. There is no doubt that nitrous oxide anesthesia as compared with ether anesthesia is a protective agent against shock.

Dr. George W. Crile of Cleveland, who is a great believer in nitrous oxide and oxygen as a general anesthetic, has this to say in regard to the anesthetic factor in shock: "Assuming that the morphological changes in the brain cells are due to the fact that nervous energy is produced by the convergence of certain chemical compounds in the brain cells into other compounds, and that this convergence of potential energy into kinetic energy is due to oxidation, then one would expect to find a given amount of trauma under an anesthetic like nitrous oxide would produce less change than an equal amount of trauma in an animal under ether, for nitrous oxide more than ether owes its anesthetic properties to its interference with the use of oxygen by the brain cells. Testing this point experimentally, we find that under approximately equal trauma the changes in the brain cells were approximately three times as great under ether anesthesia as under nitrous oxide anesthesia. That the fall of the blood pressure was on the average two and one-half times greater under ether than under nitrous oxide, and, finally, that the condition of the animal was better after trauma under nitrous oxide than after equal trauma under ether. In the course of operations on the human body one observes constantly the same protective effect of nitrous oxide."

BLOOD PRESSURE UNDER NITROUS OXIDE-OXYGEN ANESTHESIA

I have taken the blood pressure of a great many patients during the induction of nitrous oxide and oxygen, and also during the course of anesthesia. I have found, as others have, that there is quite an increase during induction, but when surgical anesthesia becomes established the pressure diminishes until it is only slightly above normal and it usually remains so throughout the operation, provided there is no great amount of surgical shock encountered. However, if asphyxia accompanies the anesthesia or enters into it to any great extent there will be an enormous increase in the blood pressure. This is not due to the nitrous oxide, but is due entirely to the asphyxiation and will diminish at once upon the asphyxial condition being cleared up. This fact must be borne in mind when administering nitrous oxide-oxygen to a patient where an increased blood pressure would be dangerous. In cases with old patients with hard arteries and normally high blood pressure, also in patients with diseased condition of the heart, kidneys, and lungs, always maintain a non-asphyxial condition in these cases, taking plenty of time for the induction and using a large percentage of oxygen.

On account of the slight increase in blood pressure, bleeding is a little more profuse under nitrous oxide than it is under ether, but this is only noticable during the first few minutes of anesthesia, and as the vaso-motor system is not affected by nitrous oxide the vessel walls maintain their tonicity and contraction takes place more readily than it does under ether.

As regards the effect of nitrous oxide upon the kidneys, Kemp states that ''contraction of the renal vessels takes place and that urinary secretion readily diminishes.'' He finds that albuminuria is produced, though not to any great extent in complete narcosis, but I have not been able to substantiate Kemp's findings and I do not believe the kidneys are affected in the least if a non-asphyxial narcosis is maintained. The secretion is not diminished and albuminuria has not been found as the result of the anesthetic *per se,* nor, in fact, any other manifestation of irritation.

ASPHYXIA DURING NITROUS OXIDE ANESTHESIA

Nitrous oxide is somewhat analogous to the atmospheric air. It has the same constituent elements and both are supporters of combustion under certain conditions. The combustion that takes place in nitrous oxide is supported by the liberation of oxygen, which decomposition is brought about by a considerable amount of heat. It must be remembered that nitrous oxide is a chemical compound and not a mechanical mixture as air; it has an action peculiar to itself and does not resemble in action the elements of which it is composed. As it requires a high degree of heat to separate it into its component parts, there is no oxygen liberated from it during its sojourn in the body, therefore, nitrous oxide is non-respirable and will not support life.

The elements of asphyxiation which we have to contend with in administering nitrous oxide is the cause of practically all the difficulties and dangers encountered in this form of anesthesia. Momentary asphyxia during nitrous oxide anesthesia is not considered dangerous in most cases.

This was generally considered part of nitrous oxide anesthesia up until the last few years and has taken place many thousand times with a remarkably, almost unbelievably, low mortality rate. The reason for this low mortality rate lies in the fact that the nitrous oxide was discontinued and the patient upon breathing the air soon obtained sufficient oxygen to clear up the asphyxial condition.

Now that we are continuing the administration of nitrous oxide indefinitely there is the danger of continuing the asphyxia as well. Herein lies the danger. The usual manifestation of asphyxia during nitrous oxide-oxygen anesthesia is cyanosis, clonic and tonic spasms, irregular and obstructed breathing, followed by high blood pressure, great general congestion, dilated pupils and rigidity of the muscles. These manifestations, however, take place only during the first few minutes of anesthesia and are readily controlled. But the most danger lies where there is a degree of asphyxia maintained over an extended period of time and the asphyxial condition is not manifested by the usual symptoms as given above. There will undoubtedly be a certain peculiar cyanosis present, but there may be no hindrance to respiration until the patient gives one or two prolonged expiratory moans and breathing ceases altogether. I believe this condition, when it arises, is due to the fact of oxygen starvation. The oxygen in the blood stream has been diminished to the point at which it supplies to the organism less oxygen than is demanded and the venous blood contains therefore little oxygen and a condition of asphyxial acidosis results. The acid substances thus formed cause the proteins of the organism to imbibe water from the blood, causing a rapid transudation of fluid from the blood vessels, also, according to Henderson, the heart muscles secrete adrenalin during asphyxial acidosis, which might result in a fatal cardiac paralysis. To prevent this almost fatal condition arising it is necessary, of course, always to use a sufficient amount of oxygen. Another phenomenon of asphyxia under nitrous oxide-oxygen anesthesia that must be interpreted correctly is the rigidity of the muscles sometimes met with. Often I have had the surgeon say to me, ''Doctor get the patient under, the muscles are rigid.'' In many of these instances if I had followed his advice I probably would have killed the patient. The rigidity of the muscles is not always caused by the patient not being under far enough, but may be asphyxial rigidity and not the result of too light anesthesia. The lack of knowledge as to the cause and handling of this condition has been paid for by the sacrifice of a number of human lives. The remedy always in such conditions is to use more oxygen and probably less nitrous oxide.

EFFECT OF NITROUS OXIDE ON THE BRAIN

I first reported the effect of nitrous oxide on the brain in a paper which I read before the American Medical Association, August 7, 1909, and have reported a number of cases of brain surgery since that time, but it may not be amiss at this time to again report the subject to you.

It is interesting and very instructive to observe the effects of nitrous oxide on the brain and also the effects of the oxygen. I have observed that when the patient inhales pure nitrous oxide the brain begins to lose its natural pinkish color in a very few seconds; if the inhalation is continued without air or oxygen the brain continues to become darker. If this is continued to the third stages of anesthesia the brain will have the appearence of stagnant blood and will be greatly dilated. The dilation is concomitant with the discoloration and if there is much cyanosis present the brain will be greatly discolored and will protrude through the opening in the skull.

All of the brain operations have shown that if the anesthetic is accompanied with asphyxia or cyanosis the brain will not only be dark in color but dilated as well; consequently I have learned that dilation and congestion were not due *per se* to the anesthetic action of nitrous oxide, but constitute an entirely asphyxial manifestation. The asphyxial factor may enter into any anesthesia, and if it does the aforementioned phenomenon will be present whether the anesthetic agent employed be chloroform, ether, or nitrous oxide.

In a non-asphyxial anesthesia with nitrous oxide there will be no dilation or congestion of the brain.

CLINICAL NOTES

Now, gentlemen, we will leave the theoretical side and see whether our investigations and theories are borne out in actual practice. Before doing so, however, it will be necessary to explain the apparatus.

The apparatus is so devised that the nitrous oxide and oxygen may be delivered to the patient with precision and accuracy, the amount of each gas given being known. There are regulators constituted in the head of the apparatus so that the gases from the small cylinders may be used with the same degree of accuracy as is secured when the gases are taken from the large cylinders, equipped with the regulators and gauges.

The frosting of the nitrous oxide as it is released from the small cylinders is obviated by means of an appliance which is so arranged that steam is forced through the regulators, thereby preventing any interference with the flow of the gas from the nitrous oxide cylinder. This warming of the regulators is not sufficient to heat the gas to the proper temperature for inhalation and it is therefore necessary to have a vapor warmer between the head of the apparatus and the inhaler. For best results, as heretofore stated, the gases should be inhaled at a temperature of from 85° to 90° F.

The nasal inhaler, as you are all aware, is used in all operations in the mouth or throat. I wish to call your attention to the exhalation valve on it. The exhalation valve is so constructed that it is always closed unless there is a certain pressure exerted upon it. It is therefore impossible for any portion of air to gain entrance during the pause between the inhalation and exhalation of the patient. On the face inhaler this principle has been worked out so that the pressure of the gases breathed may be controlled. Better and safer anesthesia may be obtained and maintained if the gases are administered under a slight positive pressure. This pressure must not be too great for it will interfere with the respiratory mechanism. The average pressure under which the best results are obtained is from six to eight mm. of mercury.

I will now give you the technique of administering nitrous oxide and oxygen for the extraction of a large number of teeth. This technique, I think, is rapidly becoming universally adopted in America.

The patient should be prepared in that he should not have had solid food for at least five or six hours before the anesthetic is administered. If only a few teeth are to be removed this does not apply. The bladder should be emptied, otherwise embarassing conditions are sure to arise. Tight collars should be removed and neck bands loosened. The confidence of the patient should, of course, be gained, the influence beginning as soon as the patient meets the assistant.

The patient should take a comfortable position in the chair. The head should be held in a straight line with the body, care being taken not put it too far back or too far forward. Either position will tend to obstruct respiration. The nasal inhaler is used in all these operations unless there is complete nasal obstruction, in which event it will be necessary to place the nasal inhaler over the mouth until anesthesia has been established. Then place it over the nose and you will be able to force a sufficient volume of gas through the nose to continue the narcosis.

You may be aided greatly by the use of surgical sponges in the mouth. Having the patient in the proper position in the chair, the nasal inhaler is adjusted over the nose, using the thumbs to spread the lower part of the rubber hood in order to prevent the partial obstruction of the nasal passages. The nitrous oxide is allowed to flow at the rate of about 150 gallons per hour. The patient is instructed to take rather long but not too deep inhalations. At the same time the oxygen is allowed to flow at the rate of about 15 gallons per hour. The oxygen bag should have been filled before the administration is commenced. It will be necessary, as a rule, to increase the amount of oxygen after the first three or four inhalations, to about 20 gallons per hour, as the conditions of the patient may indicate.

The patient will pass into the anesthetic state in from one to two minutes. The mouth prop is inserted after the adjustment of the inhaler. The mouth being open, the patient is instructed to breathe through the nose, relax and go to sleep.

If mouth breathing be noticed and persisted in after the patient is told to breathe properly, place at once a piece of rubber over the mouth, which will compel proper breathing, carrying the patient to the required depth of anesthesia. Now, remove the rubber from the mouth. Should the patient then commence to breathe through the mouth, the exhalation valve on the inhaler should be closed and the nitrous oxide and oxygen forced more rapidly. The inhaler is held firmly over the nose and the gases forced through the nasal passages under sufficient pressure to exclude the atmospheric air. The patient is then compelled to receive the gases into the lungs, even though he be inhaling and exhaling through the mouth. This is known as pharyngeal-insuflation anesthesia. Less oxygen may be necessary under these conditions than would be the case if the patient breathed continuously through the nose, because a certain amount of air gains entrance.

The mouth-breathing can be controlled to a certain extent by using surgical sponges. These sponges are used for taking care of the blood. One or more may be packed in the back of the mouth, thus compelling, to a certain extent, nasal breathing. I have found these to be a great help in work of this kind. They also serve another purpose, which is of great advantage and safety; that is, they prevent the flow of blood into the throat. A few such accidents have been reported with very serious results. Care must be taken not to pack the sponges too far back, because they will shut off the opening into the nostrils, and the patient will, therefore, not receive the gases. This will cause complete obstruction in breathing as well.

By continually forcing the nitrous oxide and controlling the asphyxial manifestations with the oxygen, the patient can be successfully kept under the anesthetic as long as may be required to accomplish the work well. Should the patient continue to breathe through the nose and not through the mouth, it will not be necessary to allow the nitrous oxide to flow faster than about 150 gallons per hour and the oxygen 20 to 25 gallons per hour. In the majority of cases, these proportions will carry the patients along in a quiet anesthesia. Unfortunately, however, cases will be met with when one's resources will be taxed to the utmost in order to anesthetize the patients successfully.

You will have patients perhaps, who will have extremely nervous temperaments and will be very much frightened. It is a peculiar fact that even the average patient is much more frightened when he sits down in the dental chair to have a tooth extracted than he is when he comes to the operating room for an operation. He has not had the preliminary preparation that he should receive before the operation, and he is therefore in a higher state of nervous tension.

The alcoholics, the strong vigorous man, the excessive smoker, are one and all hard to anesthetize with nitrous oxide and oxygen. It is out of the question to obtain a quiet, profound anesthesia in such cases. These cases can, however, be anesthetized successfully, and all dental extractions can be done painlessly without preliminary narcotics, if attention be paid to every detail and sufficient time be taken to put them well under. All atmospheric air must be eliminated, and a rather small amount of oxygen used at first, just enough to prevent asphyxial spasms of the muscles, etc. It is impossible to induce anesthesia in these cases if the patient be kept in a pink condition, for more or less cyanosis is essential during the induction, but as a rule this may be cleared up to a considerable extent as anesthesia progresses. It is not unusual to consume from three to four minutes in putting such patients under. Mouth breathing must be guarded against, not only during the induction, but also during the work in the mouth.

It is necessary to have an assistant trained in this work, for it is out of the question for a man to expect to administer the anesthetic and do the operating work at the same time. Analgesia, but not anesthesia, may be controlled without an assistant.

The inhaler should be held so that perfect co-aptation is secured at all times. The assistant may control the proportions of the gases as instructed by the operator.

No word should be spoken during the induction of anesthesia excepting when directed to the patient. The only person to talk at this time should be the operator. What he says should depend upon the temperament of the patient, since he is anxious at this time for encouragement and assurance.

Tell him to breathe naturally, but not too deeply; to relax and try to go to sleep. Assure him that it is not unpleasant or dangerous and that he will feel nothing. Assure him you will watch him closely and everything will be all right. Your patient will probably be unconscious within fifteen or twenty seconds, so you do not have to keep this talk up very long. If he resists at all, be firm with him and impress upon him the fact that he is only adding to his own discomfort. Do not force an adult to take the anesthetic if he will not do as you tell him. It is far better to dismiss him. Tell him you will gladly administer the anesthetic when he has made up his mind to come in and do as you say. He will return at some later time and give you no trouble.

In such work as the removal of tonsils and adenoids, I use, in addition to the nasal inhaler, the mouth tube. On these occasions I induce anesthesia with the mouth closed until the proper degree of anesthesia is obtained. Considerable time is taken to establish anesthesia in these cases for the reason that the throat reflexes are the last to be abolished. It usually takes from three to four minutes to establish surgical anesthesia. Just before the mouth of the patient is opened I close the plunger on the expiratory valve. By turning the small wheel on the top of the ether attachment half way around, the gases are forced not only through the nasal inhaler but also through the mouth tube.

I have found that the pressure of the gases, sufficient to produce anesthesia for this particular kind of work, when forced through the nose of the patient, was so great that it splashed the blood into the operator's face. By forcing the gas through the nose and also through the mouth, this extremely objectionable feature is eliminated. Owing to the nature of the operation a large amount of gas is necessary because of the continuous flow which must necessarily be under considerable pressure.

When using nitrous oxide from cylinders, the regulators will frequently get very cold and the gases will have a tendency to freeze up. This interferes with the even flow of the gases, but may be easily overcome by simply placing a spirit lamp beneath the regulator and allowing the flame to reach the under side of it. Care must be taken that this does not get too hot, for if it does the hard rubber seat will be spoiled and the regulator put out of order. About a one-half inch flame will produce sufficient heat.

If a child be in the chair, you will find that by using a roller towel, the child may be held in position and unable to throw up its hands or slip down in the chair. Good results cannot be secured if you are being interfered with when giving the anesthetic. This towel is put over the lap of the patient and over the back of the chair. The operator places his leg through it. Pressure may be exerted on the towel when necessary and the child will not be aware that he is being forcibly held. I never use straps, for in so doing the patient becomes frightened and the element of fear will enter into the procedure to a much greater extent.

If there is partial nasal obstruction, a slight pressure is used on the gases and the nitrous oxide is allowed to flow at the rate of 180 gallons per hour and the oxygen at the rate of from 20 to 30 gallons per hour.

The reason this large amount of gas is used is because there is not a clear airway and if an increased volume of gas be not given the patient will experience difficulty in breathing properly and will give more or less trouble during the induction.

Before I remove the piece of rubber from the mouth I turn on a larger volume of nitrous oxide and close the expiratory valve. The gases are now forced through the nose but the patient is probably breathing through the mouth. A sufficient amount of pressure may be used to maintain anesthesia even though the patient be inhaling and exhaling through the mouth. Much better results may be obtained, however, if surgical sponges are used in this connection.

The success in administering this anesthetic depends upon the minuteness with which every detail is carried out. It is an anesthetic of details.

You must be on the lookout for leakage of air. You must see that there are no obstructions in the air passages and that proper proportions of the gases are being maintained.

When the element of asphyxia enters into the procedure there is either an obstruction in breathing or you are giving too much nitrous oxide and not enough oxygen. The remedy is to always increase the amount of oxygen and remove any obstructions in the breathing.

Should a patient have a heavy mustache or whiskers, it is quite difficult to produce good anesthesia as air usually gains entrance. With the nasal inhaler you usually prevent the entrance of air even if the patient has a heavy mustache, but if you are compelled to use the face inhaler, it is almost impossible to keep the air out unless some means be taken to exclude it. This may be done by using vaseline or wet towels.

It depends much upon the mental attitude of the patient whether he takes the anesthetic well or not. There is a great deal of difference in the temperament of patients. Excessive smokers give as much trouble at times as alcoholics or ''dope fiends.''

Be on the lookout for leakage in the oxygen bag, as this may prove serious. It would be impossible to get sufficient oxygen to the patient should there be much of a leak in the oxygen bag.

Do not try to produce surgical anesthesia in dental work, for this is not necessary. Simply try to eliminate all movements of the patient and produce unconsciousness.

The method of obtaining analgesia is very simple indeed. Go about it with the same degree of accurateness as you would in producing anesthesia. A lesser amount of both bases is used, since the patient breathes about 80 per cent of air in this state.

Do not be in a hurry to produce analgesia, because you will have far better results if you take more time. It will require from three to five minutes to obtain a satisfactory stage of analgesia. About 20 to 25 gallons per hour of nitrous oxide and 8 to 15 gallons per hour of oxygen (with an open air valve) are the proper proportions for this stage. The amounts do not have to be exact, as the degree of analgesia may be controlled by allowing more or less air to be mixed with the gases.

Place the inhaler with the air valve open, on the patient's nose and turn on the proper amount of gases. Instruct the patient to breathe through the nose. You may then give your attention to getting your instruments ready and looking after any other detail that may be necessary for the operation. In three or four minutes you will find the average patient in an ideal analgesic condition.

The exceptional case may become almost unconscious with even this small amount of gas and large amount of air. In such cases, increase the oxygen to 30 or 40 gallons per hour and it may be necessary to give a smaller amount of nitrous oxide. There are other cases where it will be necessary to increase the amount of nitrous oxide slightly, and it may also be necessary to decrease the amount of atmospheric air. The latter is accomplished by closing the air valve slightly. By this the patient is compelled to rebreathe the gases to a considerable extent, which will result in a more profound analgesia. You must insist that the patient breathe as near normally as possible. He must not breathe shallow or excessively, if good results are to be obtained.

If the patient is not carrying out your instructions along this line, it is advisable to discontinue your efforts to work him. The probabilities are that he will return at some future time and do exactly as he is told.

I wish to emphasize the fact that analgesia is not anesthesia and that, unless your patient remains conscious all the time, you are not producing analgesia, but have established anesthesia.

Analgesia is perfectly safe and may be used under any and all conditions without danger, but any drug which will carry the patient to the stage of unconsciousness is not perfectly safe and must not be used indiscriminately and for any length of time.

In producing analgesia or anesthesia the average operator is rather nervous and therefore does not take sufficient time to produce these conditions. The patient suffers unpleasantness because of this fact, since he does not have sufficient time to adjust himself to the new conditions. Do not hurry but *wait.*

When producing anesthesia with nitrous oxide there is always a slight degree of cyanosis, hence a sufficient amount of oxygen should be given to eliminate congestion and extreme cyanosis.

In surgical work it is advisable many times to use a small percentage of ether vapor with the nitrous oxide. This will produce a more profound anesthesia. A sufficient amount of oxygen should be administered at the same time to eliminate all traces of cyanosis, the features of the patient remaining pink.

For the beginner with nitrous oxide and oxygen in general surgical work, it is much safer to at first use from 4 to 6 per cent of ether vapor with the nitrous oxide and oxygen. As experience is gained, gradually use less ether. It is never necessary to use ether with nitrous oxide for the extraction of teeth.

If there is asphyxia during anesthesia, increase the oxygen. If it be due to obstructions, remove the obstructions. If it be due to too much nitrous oxide, decrease the amount of this gas. In any event, the increase of oxygen is necessary until the asphyxial condition be cleared up.

Practically the only danger from nitrous oxide is asphyxia, that is, if the nitrous oxide that is given be pure. It is very important that the administrator know the symptoms of asphyxia and be able to distinguish between asphyxial rigidity and rigidity from too light anesthesia.

There was a death in one of the hospitals in Cleveland last summer. One of the internes was administering nitrous oxide and oxygen to a patient for the removal of the appendix. The interne was unable to distinguish between asphyxial rigidity and rigidity from too light anesthesia. The surgeon, supposing that the anesthesia was too light, demanded that it be deepened. The interne, attempting to do so, deepened asphyxia and death ensued.

It is necessary that one administering the anesthetic knows at all times the physical condition of the patient; knows what is producing certain conditions and, furthermore, knows when it is not safe to deepen anesthesia.

The symptoms of asphyxia are easily recognized. The patient is cyanotic, the mucous membrane of the lips and ears very dark, the muscles rigid, and the pupils dilated. The remedy under such conditions is to give more oxygen.

QUESTIONS AND ANSWERS AT LECTURES GIVEN FOR THE DENTAL DEPARTMENT OF THE UNIVERSITY OF CALIFORNIA

January, 1914

Q.—Have you ever used Bromural as a preliminary narcotic?

A.—I heard of this preparation for the first time yesterday. I have used almost everything that is on the market for this purpose, but I have not used Bromural.

Q.—How are the gases warmed?

A.—For obtaining the proper degree of temperature of the gases when they reach the patient, the gases are required to pass through a copper tube about thirty-six inches in length which is immersed in hot water. If this water be kept a little below the boiling point, the gases will be delivered to the patient at a temperature of 85° to 90° F. This method of warming the gases should not be confused with the heating necessary to prevent frosting of the valves produced by the nitrous oxide as it is released from the cylinders. The frosting of the gases in my apparatus is prevented by a mechanism which forces steam through the regulators. If the gases are being used from large cylinders the frosting may be eliminated by a simple method of hanging a spirit lamp beneath the regulators. A half-inch flame will furnish sufficient heat to prevent frosting. You take no risk in overheating the regulators when using so small a flame. The danger in overheating would be, that the hard rubber seat of the valve in the regulator would be spoiled.

Q.—How can you determine the purity of the gases?

A.—The most practical test is the "olfactory test." It is not unusual to detect slight impurities in nitrous oxide by the odor even after the ordinary chemical test shows no trace of impurities. The usual impurities found in nitrous oxide are chlorine and some of the higher oxides. The odor of such gases is very pungent and is easily detected. When starting to use from a small cylinder of gas I always inhale some of it to determine its purity. Should it have any other odor than a slightly sweet smell, I would hesitate to use it.

Q.—Is it possible to detect two per cent of impurities?

A.—It would depend upon the impurity. Should there be a leakage of air into the gas, an impurity could not be detected by the olfactory test, but two per cent or much less of nitric oxide or chlorine would be readily detected by this method.

Q.—Do you always begin with a mixture of oxygen and nitrous oxide?

A.—Both gases are administered practically simultaneously, although a much larger proportion of nitrous oxide is to be given. The oxygen is slowly increased, beginning with about 8 to 12 gallons per hour, gradually increasing this to about 20 to 25 gallons per hour, as may be indicated, as anesthesia is continued. If I had an extremely nervous patient or an alcoholic or ''dope fiend,'' I would withhold practically all oxygen until I had control of the patient, for it is important in these cases to establish anesthesia quickly. You undoubtedly will have a considerable amount of asphyxia as well as anesthesia, but the former may be readily eliminated by increasing the oxygen. As I told part of this class, when you establish a reputation in administering nitrous oxide and oxygen, you undoubtedly will be called upon to go to a hospital to administer this anesthetic. In all probability, the first patient you will have will be almost dead and you will be expected to keep him alive. In such serious cases you must employ a technique different from that which you would ordinarily use. I would start by giving pure oxygen and gradually increase the nitrous oxide and decrease the oxygen until I secured good anesthesia. In this way you will not kill the patient during induction of anesthesia, as could very easily be done if the usual procedure were carried out.

Q.—How long should you administer pure oxygen?

A.—Pure oxygen may be administered for a considerable period of time if given intermittently with air. The continuous inhalation of pure oxygen should not exceed two minutes. However, after a lapse of two or three minutes, this may be repeated a great many times in a similar manner.

Q.—Are there any bad after effects from pure oxygen?

A.—If the above method be carried out there will be no bad after effects from inhaling pure oxygen. It is impossible to produce bad after effects if the gases be breathed as before explained, for a reasonable length of time, say from ten to twelve minutes.

Q.—Do you consider nitrous oxide and oxygen dangerous to administer to a patient who has a diseased heart?

A.—In cases of heart trouble or apoplexy, nitrous oxide and oxygen is practically safe if all asphyxia be eliminated. If a sufficient degree of anesthesia cannot be obtained in this manner, it is much safer to use a small percentage of ether to secure the proper relaxation and a larger percentage of oxygen, which should entirely eliminate asphyxia.

Q.—Does nitric oxide in the cylinder indicate that the gas is impure?

A.—There is no nitric oxide in nitrous oxide unless it be impure. Since it takes a high degree of heat to separate nitrous oxide in its component parts, there is no breaking up of this gas in its passage through the organism.

Q.—Is there any difference in the method of administering nitrous oxide and oxygen at high altitudes?

A.—In high altitudes, the lungs have adjusted themselves to a lower percentage of oxygen. The difference is practically so slight that it is not noticeable in administering nitrous oxide and oxygen.

Q.—Are there always more or less impurities in the gases?

A.—No. I have only found three or four cylinders in the last two years which contained impurities.

Q.—Has the condition of the patient any bearing on the way in which the anesthetic should be administered?

A.—Only the extreme conditions have a bearing in this connection—the very old and the very young. I would proceed in the same manner for both extreme ages. The non-asphyxial anesthesia must be produced, it being much safer to use two or three per cent of ether in these cases, if profound anesthesia is to be obtained. Unless the operator be skilled in administering this anesthetic it would not be safe to administer it to babies. The reason is that they are thrown into the asphyxial condition readily and a condition is brought about resembling an epileptic spasm. This could be obviated by administering a larger percentage of oxygen. Sufficient anesthesia may be obtained by a small percentage of nitrous oxide and two or three per cent of ether. If epileptic spasms should arise the treatment should consist in keeping the inhaler in place and administering pure oxygen until it subsides. The anesthetic may then be cautiously given, care being taken that the asphyxial element does not again appear. In old people, on account of the danger from increased blood pressure which always takes place when the patient is in an asphyxial condition or cyanosed, it is absolutely essential that asphyxia should be eliminated in these cases.

Q.—What position should be maintained during the operation?

A.—The position of the patient makes no difference providing it does not interfere with maintaining a clear airway. In throat work there is a considerable amount of blood encountered. The patient must therefore be in a position to prevent the blood from entering the trachea. In these cases the patient should be in a recumbent position, the head slightly lower than the body, and turned slightly to the side. In this way the blood will not enter the trachea and interfere with the breathing. The tongue should not be crowded back. It may be necessary to call the surgeon's attention to the fact that the patient must at least be allowed to breathe a little. The surgeon often becomes so interested in his part of the work that his manipulation interferes with the patient's breathing. This may be done by crowding the tongue too far back or opening the jaws too wide or by inserting sponges to control hemorrhages. The surgeon cannot assume the responsibility of administering the anesthetic, although he may be willing to do so. It is the anesthetist's business to see that nothing transpires that will endanger the life of the patient in so far as the anesthetic is concerned.

Q.—For anesthetic work may the rubber dam be used?

A.—Yes, sir. You may control the breathing better if the rubber dam be in place, for the patient will then be compelled to breathe through the nose.

Q.—Is there any danger in administering nitrous oxide during pregnancy?

A.—The only danger in administering nitrous oxide when the patient is in this condition is from asphyxia. If in administering the anesthetic all asphyxia is eliminated, it is perfectly safe. It is essential that a patient in this condition take the anesthetic without struggling. I always insist that unless she is willing to do exactly as I tell her while she is conscious I will refuse to give her the anesthetic. After the second stage of anesthesia has been passed a light and quiet anesthesia should be maintained which must be void of asphyxia.

Q.—For an alcholic drinker how would you proceed?

A.—I would use a large amount of pure nitrous oxide and put him under as soon as possible and then I would admit oxygen to eliminate asphyxia.

Q.—When you use a heavy pressure through the nasal apparatus, would there be any danger of wounding the patient?

A.—No. For the reason that we do not use heavy pressure through the nose unless the mouth of the patient be open. Therefore there would be no pressure exerted upon the lungs. I could illustrate this by taking a tube with a large hole in the middle of it. Under such conditions there could be no undue pressure at the other end of the tube, as the gas would be released through the hole in the middle.

Q.—Do you sterilize the bags on the apparatus?

A.—In anesthetic work it is not necessary to sterilize the bags, for it is impossible for the rebreathed gas to get back into the bag on account of the large volume of gas continually flowing outwards, but in analgesic work it may be possible for some of the rebreathed gases to enter the nitrous oxide bag and if you wish to be careful in carrying out asepsis it would be advisable to sterilize the nitrous oxide bag. It is not necessary to sterilize the oxygen bag, for the reason that a check valve is so placed in this bag that no gas can enter it except from the oxygen cylinders. The best method of purification for rubber is to immerse in in 20 to 30 per cent lysol solution for an hour or so. This will not only sterilize the rubber but will keep it in a soft, pliable and velvety condition. We have had a number of tests made to see if infection could be carried through the bags and tubing become infected by the process of rebreathing. We were unable to grow a culture taken anywhere but from the upper third of the tube leading from the inhaler to the apparatus. Therefore to obviate the possibility of carrying infection it is necessary to sterilize only the inhaler and tubing.

Q.—How long does it take to eliminate nitrous oxide from the system?

A.—I have never had blood tests made for this purpose, but from my clinical observations, I would say in about fifteen minutes. This time may be hastened after a long operation by allowing the patient to breathe pure oxygen for a minute or two. This is my usual procedure and it greatly hastens the elimination of nitrous oxide.

I have been asked to speak about what is known as Anoci-association as brought forward and practiced by Dr. George W. Crile, of Cleveland. It has been my pleasure to work with Dr. Crile for a number of years and I am perfectly familiar with his wonderful technique. I will describe in his own words what is meant by anoci-association.

''On these foregoing premises the kinetic theory rests. On the kinetic theory a new principle of operative surgery is founded. This principle can best be expressed by coining a new word, viz., anoci-association. An adequate stimulus with or without inhalation anesthesia, whether from trauma or from emotion, causes the brain cells to discharge some of their stored energy, that is to say, the sight of the operating room, the spoken word implying danger, the taking of the anesthetic, the instrumental injury of the tissues in the course of the operation, and the traction of the stitches after operation, all are adequate stimuli. Therefore, the stored energy of the brain cells is consumed during surgical operations and during psychic strain. Obviously the only practical method of preventing the consumption of this stored energy of the brain cells is the development of a principle of operative surgery the practice of which will exclude from the brain the stimuli of the special senses and the stimuli of the common sensation. This is the principle of anoci-association, meaning the exclusion of all nocuous or harmful associations or stimuli.''

The usual procedure that is carried out in the extremely bad-risk cases is as follows: In the first place, the operator tries to eliminate the fear of the patient, since it has been proven, without a doubt, that fear causes considerable degree of shock, and so he wishes to eliminate fear as much as possible in all operations. In case of a goitre, he will take his patient to the hospital and keep him there for about two weeks, making trips to the operating room a number of times for treatment. He goes through the operation of scrubbing the neck while he puts the nitrous oxide apparatus over the face and lets the patient breathe air or oxygen. Of course, he is not getting the anesthetic, but he is going through the same procedure that will be gone through at the time of the operation. Each morning the patient is given a hypodermic injection of sterilized water. A heart stimulant could, however, be given at this time if it be necessary. On the morning of the operation the patient is given a hypodermic of scopalamine and morphine, the dosage depending upon the physical condition of the patient, providing there be no idiosyncrasy against drugs. One-half hour before the patient is brought to the operating room, a second hypodermic is given, using the same drugs. The patient is really not aware that he is being taken to be operated upon. The inhaler is placed over the patient's face and the patient, being already in a subconscious condition, is not aware of what is taking place. The field of operation is prepared with an injection of novocain, which is less toxic than cocain, hence a much better anesthesia is obtained.

It is amusing to see how many men have given this system a trial for a brief time only, and then express adverse opinions as to its merit, but such opinions are due to the lack of a full understanding of the proper technique. I am of the opinion that it is one of the greatest discoveries in modern surgery.

Q.—What per cent of novocain do you use?

A.—One in four hundred.

Q.—Do you use quinine-urea hydrochloride?

A.—No.

Q.—Does Dr. Crile use quinine-urea hydrochloride as a local anesthesia?

A.—Upon the completion of some of his operations he uses quinine-urea hydrochloride in order to maintain for some time a condition of local anesthesia, but I understand he is using it less frequently now than formerly.

Q.—Will you give your reasons for using pantopon and morphine.

A.—It is a routine practice in ninety per cent of the leading hospitals of the country to give some narcotic as a preliminary to general anesthesia. The reasons for this are too numerous to mention at this time. The principal reason is that the patient will be quieter, and further that a much less amount of general anesthetic will be necessary. I prefer pantopon to morphine because less nausea follows the use of pantopon than when morphine is used. The usual dose of pantopon is from one-third to one-sixth grain. One-third of a grain of pantopon is equal to one-fourth grain of morphine.

Q.—What is the difference in the action between scopolamine and pantopon?

A.—Scopolamine has not as great anodine effect as pantopon. Scopolamine is used to prevent inhibitory stimuli reaching the heart, where pantopon is used to deaden the nerve centers and the finer sensibilities resulting in the patient being put into a tranquil mood.

Q.—Do you ever have any trouble with scopolamine?

A.—No, I have not.

Q.—In inducing analgesia you speak of a certain percentage of nitrous oxide and oxygen.

A.—I should have spoken of the percentages of air as well. The average percentages that are used in producing and maintaining analgesia are 20 per cent nitrous oxide, 5 per cent oxygen and 75 per cent air.

Q.—Why do you not get as good results with nitrous oxide and air?

A.—I do not know the physiological reason why as good results are not obtained when using air alone, but from practical experience I know that we do not obtain nearly as good results as we do when oxygen is being used. When using oxygen in addition to the air we get more profound analgesia, still having the patient entirely conscious. Normal oxidation is not interfered with to the extent that it would be if pure oxygen were not being given.

Q.—Is it practical to extirpate a pulp during analgesia?

A.—No, not as a general rule. It is far more satisfactory to induce anesthesia for this line of work. I do not advocate the extraction of nerves from multiple-rooted teeth under anesthesia, for I do not consider the necessity sufficient to subject the patient to the dangers of prolonged anesthesia. I would recommend in such instances the opening up of the pulp chamber and the doing of the balance of the work under cocain pressure anesthesia. In single-rooted teeth this work may be satisfactorily done under nitrous oxide-oxygen anesthesia. I wish you to remember that while it is safe to prolong analgesia, it is not safe to prolong anesthesia.

Q.—Is it possible to produce injurious effects upon yourself when you are administering nitrous oxide from inhaling the exhalations?

A.—For twelve years I have sat at the head of patients who were being held under the effects of nitrous oxide anesthesia and, of course, have been compelled to breathe to a certain extent the exhaled gases, but I have never experienced any injurious effects whatever. However, I refuse to get under a sheet which is thrown over the head of the patient, as is sometimes practiced, for I consider it very unsanitary and, furthermore, it is likely to produce injurious effects if persisted in for any length of time.

Q.—As regards anesthesia, do you ever find a patient you cannot anesthetize with nitrous oxide and oxygen?

A.—There is not a patient living that cannot be made unconscious wtih nitrous oxide, but there are many who cannot be completely relaxed with nitrous oxide.

I have never had a patient I could not sufficiently anesthetize so that he would feel no pain. It is often necessary to take considerable time in producing anesthesia in these exceptional cases. Usually, insufficient time is taken, and an uneven mixture of the gases are given in securing anesthesia in these cases.

A patient came into my office to have a tooth extracted and said, "You will have to tie me down, Doctor, for whenever they try to give me an anesthetic I become crazy and try to jump out of the window." I had him sit in the chair and put a strap around him which securely held him there. In handling such cases, I administer the pure nitrous oxide for the first half minute or so in order to secure anesthesia as quickly as possible, then admit the oxygen slowly, gradually overcoming asphyxia, as this generally accompanies this method of administration. In this way, I secured a good anesthesia in this case and in all other such cases.

Q.—In case you have a lot of dental work to be done under analgesia would it be necessary to put the patient in this state five or six times or would you hesitate to use analgesia until you were through?

A.—I consider that there would be no harm done if you do not use it too long at each sitting. I would not hesitate to administer it in the morning for half an hour and again in the afternoon for a half hour or so.

Q.—How would you proceed in giving this anesthetic to a very sick person?

A.—If the patient were to have dental work done, I would first assure myself that the patient could withstand the shock as a result of the trauma produced in doing the work. If he could, I would administer the anesthetic without any hesitancy. I would start the anesthetic with a larger per cent of oxygen, gradually decreasing it until I had secured light anesthesia. I would always administer a sufficient amount of oxygen to prevent the possibility of the interoccurrence of asphyxia.

Q.—Do you think analgesia for cavity preparation will be used generally?

A.—I most assuredly do. It is bound to come, as it is the safest way that we know of at the present time whereby it is possible to do painless dentistry.

Q.—What do you do if there is a great deal of blood present in the mouth?

A.—I use surgical sponges to wipe out the blood. I pack one or more of these sponges in the mouth in order to prevent the flow of blood into the throat.

Q.—Would there be a case in dental operation when you would be justified in giving ether?

A.—Yes, there are quite a few cases where you will be able to produce a safer and more satisfactory anesthesia by supplementing the nitrous oxide with a small percentage of ether.

Q.—In what cases would ether be contra-indicated?

A.—Where there is any kidney or bladder irritation or lung inflammation such as may be present during an ordinary cold.

Q.—Do you use a hypodermic of pantopon before every anesthetic?

A.—I do not use a hypodermic of any kind before an anesthetic for dental operations, or only in the exceptional case. A hypodermic is always used if a major operation is to be performed.

Q.—Do you give a narcotic to children for adenoid operations?

A.—No, it is not necessary.

Q.—What is the mortality rate under this anesthetic?

A.—I am unable at this moment to answer this question, but I would be glad to refer you to Dr. James T. Gwathmey's work on ''Local and General Anesthesia,'' wherein he has just finished compiling data along this line. As I remember it, he gives the mortality rate under nitrous oxide as one death in 48,000; ether, one death in a little over 12,000; chloroform, one death in a little over 4000. I am sorry to say that I believe the mortality rate under nitrous oxide and oxygen, used by medical men little skilled in its administration, is very much higher than that given by Dr. Gwathmey. It is not an easy matter to administer nitrous oxide and oxygen in major surgery and medical men will kill a number of patients before they realize that it is necessary to study the subject a little. A great many men think that all they have to do is to get an apparatus and go to work. This is a great mistake, for there will be a high mortality rate until it is generally recognized that nitrous oxide and oxygen is the safest anesthetic only when administered by one skilled in its administration. My experience has taught me that dentists make the best anesthetists with nitrous oxide and oxygen, this being due, I presume, to the fact that dentists are much more familiar with this anesthetic than are physicians. In all the administrations of nitrous oxide that I have had there has been but one fatal case and you will see from the following report that it was not an anesthetic death.

This case that I had occurred about four or five years ago. It was an exploration operation. The patient was an invalid for years and as a last resort consented to have an operation to see what was the matter. She was in a bad condition, had not taken solid food through the mouth for six weeks, so you can therefore imagine the physical condition of the patient to start with. I should have refused to give the anesthetic, because she would not stand the shock of the operation. Dr. Crile's system might have worked, but I think not. I started anesthesia by pure oxygen and gradually increased nitrous oxide. Immediately she was in profound anesthesia. I was giving more oxygen than nitrous oxide and I said to the surgeon, "This woman does not need an anesthetic." He had made his incision in the abdomen. The pulse was improved from the stimulating effect of the operation. In starting an operation the pulse is generally better from the stimulating effect. She was getting along fairly well. We put her in the Trendelenburg's position—head lower than feet. Her respiration was good. The operation probably took forty minutes. I put the patient's hands across her chest. The surgeon requested them off, but I noticed that the fingers and hands were black. The color was good in the face, but the dark color was creeping up the arms. The surgeon said it must be the position of the hands. There was no sound of the heart. I gave nothing but pure oxygen and got a red streak through the dark color of the skin. I wondered if I could give too much oxygen, because I had never before come across such a case. The respiration was very shallow and gradually ceased. I gave oxygen for forty minutes afterwards, but the patient was dead. The death was absolutely from shock. The patient might have lived a short time if the surgeon had closed up, but he persisted. We would have been able to get her off the operating table, but she would have died. The operation lasted in all about fifty-five minutes.

Q.—In regard to the use of nitrous oxide and oxygen for analgesia, do you consider it contra-indicated during menstruation?

A.—It is not contra-indicated during this period, but good results cannot be expected at this time on account of the increased nervous condition of the patient.

Q.—Would you administer nitrous oxide and oxygen to a patient with a light cold?

A.—There is nothing better for the cold than a short inhalation of warm nitrous oxide and oxygen.

Q.—Do you think it advisable to encourage dentists to take up nitrous oxide and oxygen not only in their own practice but in surgery?

A.—I most emphatically do. I would have been greatly handicapped in developing this form of anesthetic if I had not gone into the surgical work early.

There is a great demand for good anesthesists with nitrous oxide and oxygen in general surgical work. I consider it a duty to lower the mortality rate from anesthesia and, as I have said before, dentists make the best anesthetists with nitrous oxide and oxygen. I do not wish to be understood that I consider every dentist to be a good anesthetist, for the facts are that this statement would be far from true, nor do I expect you men here, after hearing this series of lectures, to become skilled anesthetists. Some of you are undoubtedly adapted to this line of work, but there are others who would never become proficient in it. However, you cannot fail to absorb a great deal of matter along this line and will be in a position to now know how a good anesthetic should be administered. A person cannot become skilled over night. It takes close and persistent application for some length of time. I hope that I have been able to open your eyes to the magnitude of this subject and have made clear to you some things that were not clear before, for I am sure you will realize that anesthesia is one of the most vital subjects that you will be called upon to cope with in actual practice.

UNIVERSITY OF CALIFORNIA

UNIVERSITY EXTENSION DIVISION

COLLEGE OF DENTISTRY

Dear Doctor:

The success of the Dental Institute held in January last under the auspices of the Extension Division and the College of Dentistry of this University was so decided that we proposed to hold two such institutes—one in Los Angeles and one in San Francisco—within the current academic year.

Lectures An invitation has been extended to Doctor Immanuel Otteson of Kristiania, Norway, to deliver a special course of lectures on Oral Surgery and Local Anesthesia. Doctor Otteson comes recommended as a clinician of very high standing in this subject.

In Los Angeles The Institute in Los Angeles will be held from December 28th to January 2nd. The arrangements for the course will include lectures to be given in the lecture hall of the College of Dentistry, University of California, at Sixteenth and Los Angeles streets, at 10 o'clock in the morning. The clinics will be given from 2 to 5 P.M. each day at the Los Angeles County Hospital, 1715 East Fourteenth street. A programme and ticket will be mailed to each subscriber prior to the opening of the course of lectures.

It is probable that at some time during the week a complimentary dinner by subscription will be given the lecturer, under the auspices of the Los Angeles County Dental Society. The profession will be welcome to attend this dinner meeting, whether they are members of the class or not.

In San Francisco The Institute in San Francisco will be held January 4th to 8th inclusive. The arrangements for the course will include a general meeting at the University, 101 California Hall, Berkeley, on the morning of January 4th at 10 o'clock. The remaining lectures will be given in the Dental School at the Affiliated Colleges at the same hour. The clinic sections will meet each day from 2 until 5 P.M., at the Dental School.

It is probable that at some time during the week a complimentary dinner by subscription will be given the lecturer, under the auspices of the San Francisco District Dental Society. The profession will be welcome to attend this dinner meeting, whether they are members of the class or not.

Fees The fees for the entire course of instruction in each Institute will be $5.00, the holders of the course ticket being privileged to attend either in San Francisco or Los Angeles. This fee must be paid in advance. On the payment of the fee, members of the class will be privileged to attend the full course of lectures and one clinic section. This arrangement is necessary, since it is impossible for the full number attending the lectures to witness the clinics with any degree of comfort or satisfaction. One-fifth of the total number of members of the class will be assigned to each clinic period.

This arrangement makes it possible for those practicing in the vicinity of the locality where the lectures are given to attend to their practice during the remaining afternoons.

Lecture notes will be published in bulletin form subsequent to the lectures, and may be had for the sum of fifty cents.

Communications All subscriptions for this course must be made payable to the College of Dentistry, University of California, and mailed to Dr. Guy S. Millberry, Dean of the College of Dentistry, First and Parnassus avenues, San Francisco. All funds received will be deposited with the Regents of the University of California, and used exclusively for Institute purposes.

A programme and ticket will be sent to each member of the class in ample time to arrange for attendance.

Very truly yours,

I. W. Howerth,

Director University Extension Division.

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UNIVERSITY OF CALIFORNIA
UNIVERSITY EXTENSION DIVISION
COLLEGE OF DENTISTRY

PROGRAMME

of

COURSE OF LECTURES AND CLINICS

by

DR. IMMANUEL OTTESON

KRISTIANIA, NORWAY

on

LOCAL ANESTHESIA
IN OPERATIVE DENTISTRY AND ORAL SURGERY

Berkeley and San Francisco, California
January 4 to 9, 1915

AT BERKELEY

MONDAY, JANUARY 4, 1915

101 California Hall, 10 a.m.

Address of Welcome.

Dr. I. W. Howert

Local Anesthetics.

Dr. Immanuel Ottes

The succeeding lectures will be given
the College of Dentistry, Affiliated College
San Francisco, by Dr. Otteson at 10 a.m. ea
day. Subjects to be announced.

AT SAN FRANCISCO

COLLEGE OF DENTISTRY, AFFILIATED COLLEGES

(*Take car No. 6 direct from Ferry*)

The clinics will be given in the Surgical Amphitheatre of the College at 2 p.m. of each day.

The class will be divided into sections, depending upon the number enrolled, and your ticket will state specifically which day you will attend the clinics.

Dr. OTTESON will demonstrate the technic of injection on clinical cases and will operate.

Members requesting the privilege will be given the opportunity of performing the different technical methods of injection.

DINNER

Probably a dinner will be arranged unde the auspices of the profession some evenin during the week. Announcement will be mad at a later date.

UNIVERSITY OF CALIFORNIA
UNIVERSITY EXTENSION DIVISION
COLLEGE OF DENTISTRY

PROGRAMME

of

A COURSE OF LECTURES AND CLINICS

by

DR. IMMANUEL OTTESON

KRISTIANIA, NORWAY

on

LOCAL ANESTHESIA
IN OPERATIVE DENTISTRY AND ORAL SURGERY

Los Angeles, California
December 28, 1914, to January 2, 1915

AT THE COLLEGE OF DENTISTRY

UNIVERSITY OF SOUTHERN CALIFORNIA

Sixteenth and Los Angeles Streets

Monday, December 28, 1914, 7:30 p.m.

Address of Welcome.

Dr. G. Maurice Cro

Extension Work in Dentistry.

Dr. Guy S. Millber

Introduction of the Lecturer.

Dr. L. E. Fo

Local Anesthetics.

Dr. Immanuel Ottes

The succeeding lectures will be given t the above location by Dr. Otteson at 7:30 p each day. Subjects to be announced. Te lectures will be omitted on New Year's D, Friday, January 1st, and will conclude Sat-day evening, January 2nd.

CLINICS

AT THE COLLEGE OF DENTISTRY

UNIVERSITY OF SOUTHERN CALIFORNIA

SIXTEENTH AND LOS ANGELES STREETS

The clinics will be given in the Surgical mphitheatre of the college at 2 p.m. of each ay, beginning Tuesday, November 29.

The class will be divided into four sections, nd your ticket will state specifically which ay you will attend the clinics.

Dr. OTTESON will demonstrate the technic f injection on clinical cases and will operate.

Members requesting the privilege will be iven the opportunity of performing the different technical methods of injection.

GENERAL INFORMATION

1. The entire class will attend the lectures beginning at 7:30 p.m. each day. These wil be given at the College, Sixteenth and Lo Angeles streets. Take Main street cars t Sixteenth street, or Pacific Electric to Hil and Sixteenth street.

2. At the close of the lecture for a perio of thirty minutes the class may present ques tions to the lecturer.

3. The class will be divided into four sec tions. Each section will be admitted to th clinic in accordance with the date on thei ticket, and at no other time.

4. It is planned to give those who desir an opportunity to participate in the clini with regard to the technic of injection. I is hoped to have a specially prepared cadave head and neck, for demonstration purposes.

DINNER PROGRAMME

A dinner will be given on Wednesda evening, December 30th, probably at th Johnathan Club, in the Pacific Electr Building. Plates $1.50. The principal speak will be Dr. OTTESON, who will deliver h regular lecture for the evening.

UNIVERSITY OF CALIFORNIA
COLLEGE OF DENTISTRY

EXTENSION LECTURES
2

LOCAL ANESTHESIA IN MINOR SURGERY AND OPERATIVE DENTISTRY

BY

DR. IMMANUEL OTTESON
Professor of Operative Dentistry, Tandlaege Institut, Kristiania, Norway.

LOS ANGELES:
DECEMBER 28, 1914-JANUARY 1, 1915

SAN FRANCISCO:
JANUARY 4-8, 1915

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1915

LOCAL ANESTHESIA IN DENTAL SURGERY

BY

DR. IMMANUEL OTTESON

For the great honor conferred upon me by the University of California in inviting me to give a series of theoretical and practical suggestions with regard to the field for local anesthesia in dental surgery, I must be permitted to express my deep gratitude.

I fear, however, that it will be a matter of some difficulty for me to give at once a brief and a comprehensive explanation of the drugs and the different methods employed in producing local anesthesia in operative dentistry and oral surgery. The foreign language and my defective pronunciation of it, are hardly likely to be conducive to a satisfactory result. Nevertheless, knowing that I have a very highly educated, interested, and as I hope, patient and indulgent group of gentlemen before me, I trust that you will understand my bad English and if there should be any point in my paper or in my clinical demonstrations which is not quite clear to you, I shall be glad to answer any questions put to me in the discussion that may follow.

From the earliest dawn of culture it has been a noble matter for the physician to relieve pain, although many centuries elapsed before suffering humanity was granted deliverance from pain under the surgeon's knife. The ancient Greek and Roman physicians were acquainted with the power of certain drugs to produce a soothing effect during surgical operations, and hypnotic sleep was also employed, but until as recently as 1846 there had not yet been used any chemical products which could give the patient ''a good sleep'' while under the operation. No doubt the great French surgeon Velpeau was expressing surgical opinion when in 1839 he wrote ''Escape from pain in surgery is a chimera which we are not permitted to look for in our day.'' ''The knife and pain in surgery are two terms which never present themselves the one without the other in the mind of the patient, and it is necessary for us surgeons to admit their association.'' Within less than a decade, on the 16th of October, 1846, we had the great so-called ''Ether Day,'' at the Massachusetts General Hospital, when Mr. Abbot was narcoticised by the dentist William Morton and the risk of the effects of the ether was taken by Dr. Warren, who performed an operation upon the lower jaw.

From that surgical amphitheatre this glorious triumph on behalf of humanity was spread throughout the world, and let us never permit ourselves to forget those two honored members of the dental and medical profession. America may be proud of being the country in which the most used narcotic products, ether and nitrous oxide, were first applied. Horace Wells used nitrous oxide in 1844, and while he did not achieve a complete success the credit which belongs to him is large and the name of Wells should always be held in honored remembrance.

Another remarkable year was 1884, when Dr. Koller demonstrated at Heidelberg the cocaine solution and its anesthetic effect. From that time and especially after the two scientists Tacamine and Aldrick—let us never forget them—had succeeeded in isolating the active principles of the suprarenal glands of oxen and had the substances prepared in crystallic form—dates the splendid development of local anesthesia.

We have the organic product called adrenalin and the synthetic called suprarenin, both with the same effect of arterial contractions and both indispensable additions to every anesthetic solution.

It would be a waste of time and I should only tire you, my dear colleagues, if I were to go in detail into the historical development of the different general and local anesthetics. Many authors east and west through the whole of the civilized world have studied and written the story of the great and remarkable development of chemistry and medical science, which has brought us up to the most ideal and sure procedure in performing general and local anesthesia.

The latter form of anesthesia is especially practical in dental and oral surgery because in operating in the mouth it is of great importance to have the patient fully conscious and I venture to say that in Europe general anesthesia in our field is employed only in certain rare cases; maybe in cases of ankylosis. This is especially so from the date of Dr. Einhorn's discovery of novocaine. Dr. Braun states that novocaine is an ideal anesthetic which not only may be employed instead of cocaine in every case, but which has materially increased the safety of local anesthesia owing to the fact that much larger quantities of this effective anesthetic may be freely injected. Up to 200 c.c. of the one per cent solution have been injected in major surgery cases and it has been perfectly well tolerated and Dr. Braun employs local anesthesia exclusively for the following operations: In the maxilla and the face, cranial resections, tracheotomies, resections and numerous other cases of major surgery. Cocaine, the first effective local anesthetic, is very toxic and a pronounced protoplasmic poison. It is contraindicated in diseases of the heart, kidneys and nerves, and it is uncertain because one can never know beforehand whether the patient has idiosyncrasies for the cocaine or not. In some cases large doses may cause a serious

W. E. CUMMER,

form of intoxication and even death. Therefore its use now is reduced to pressure anesthesia for pulp and to superficial anesthesia of the mucous membrane where its toxic properties can not exert themselves. Even in those cases a toxic effect of the cocaine can be noticed. These arguments have stimulated many scientific chemists to discover a substitute for cocaine and in recent years a number of such substitutes have been brought into the market. I may mention alypin, eucain B, tropacocain and many others. Among all of these novocaine holds the first place as an ideal anesthetic. It is a salt in the form of white powder soluble in water and as little toxic as possible in proportion to its anesthetic power. It is seven times less toxic than cocaine. It causes no change in the tissue. *It may, in contradistinction to cocaine, be boiled many times without detriment.* It can be used in combination with adrenalin or suprarenin. It may be introduced directly into wounds without damage and it has a soothing effect in after-pain, following upon surgical trauma. It is rendered useless by alkalies, so the syringe ought to be boiled in distilled water. The addition of synthetic suprarenin increases the effect of the anesthetic power and prolongs the duration of the anesthesia. Unlike the suprarenal extracts, which are decomposed by temperature, light and air, the pure novocaine solution is very stable. For this reason the synthetic suprarenin also is used in tablet form and not in aqueous solution. Decomposed suprarenin solution, easily known by its reddish color, must not be injected because it is very toxic.

Another very essential thing is the composition of the solution in which the novocaine and suprarenin are dissolved. This solution ought to be so chemically composed that it will pass the tissue cells without damage. It must be physiologically perfect so that it can be absorbed without any reaction. Pure water cannot be used because it disturbs the cells and tissues in the injected area. If, however, we add a quantity of such salts as make up the cells—for instance sodium chloride in its physiological solution (0.92 per cent)—this solution will not cause any irritation of the cells and tissues and will be absorbed freely. A still more suitable solution is the so-called Ringer solution, containing besides sodium chloride also small traces of calcium and potassium chloride. The last two salts also constitute the physiological composition of the tissue fluids and the protoplasm. Especially the calcium has an increasing effect on the vital function of the leucocytes, this salt being of prime importance in phagocytic acid resistance to infection. I fully agree with Dr. Fischer when he says that the addition of calcium chloride to the injection solution has given so much satisfaction that he would not care to return to the pure sodium chloride solution. He has used Ringer's solution for two years and has found that it has a most favorable influence upon the absorption of the anesthetic even in complicated cases. It increases its penetrating power and materially contributes to rapid and safe healing. In all cases of difficult absorption, in which formerly edema and after-pain used to occur, untoward secondary effects have been reduced to a minimum, or have been done away with by the use of Ringer's solution. This solution is isotonic and being always injected at the blood temperature, it will not harm the tissue in that way. The following formulae for the solution may be recommended:

Sodium chloride,	0.5 grams
Calcium chloride,	0.04 grams
Potassium chloride,	0.02 grams
Aqua distillate,	100 c.c.

As a rule, I take 5 c.c. of this solution and add 0.1 gram of novocaine, making a two per cent solution which is suitable in most cases. To this solution add from two to five drops of suprarenin—boil it and draw it *from the jar in which it is boiled* direct into the cold sterilized syringe, the temperature thereby being reduced to about the temperature of the tissue. The surface of the mucous ought to be sterilized as well as possible by painting the place of insertion of the needle with dilute iodine solution or still better tinct. aconite and tinct. iodine, equal parts. An injection made under such precautions may be regarded as perfect so far as the fear of infection is concerned and among hundreds of intra-alveolar injections in which the solution is injected into the spongiosa, I have not yet seen a single case of infection. The swelling and after-pain you may notice in oral surgery must certainly be attributed to the trauma or infection of some kind because, as you know, the mucosa is very difficult to sterilize. As regards the duration of the anesthesia it is different in different methods of injection and individuals. I have observed a variation in the duration of from about ten minutes at the shortest to forty minutes at the longest. As a rule there will be time to perform the different operative work. In the intra-alveolar injection I have sometimes prolonged anesthesia by injecting more of the anesthetic solution through the hole drilled into the spongiosa.

Figure 1 shows my injection equipment, a very important matter in the field of local anesthesia. From the left to the right you see first the glass jar with the syringes. In the jar is alcohol, or you may use a mixture of three parts alcohol to one part glycerine. As regards the syringes I find it very important to have a syringe which may be boiled without being destroyed. I prefer the all-metal and glass syringe without a leather washer as advised by Fischer (fig. 2). It is built strongly, can be taken to pieces entirely and the condition of the injection solution can be controlled. Preserved in alcohol between the injections it will remain sterile. A very essential part of the syringe is the needle. It must be sharp and strong and easily mounted on the different attachments. The iridio-platinum needle is the best, but nickel needles also do good service. Many dentists use steel needles, but this I find too dangerous because they rust and may easily get broken. To remove broken needles from the spongiosa or from the mandibular sulcus is a very difficult thing, so we ought to do our best to prevent such fatal occurrences. We use short needles for mucous and spongiosa anesthesia and long ones (17 mm.)

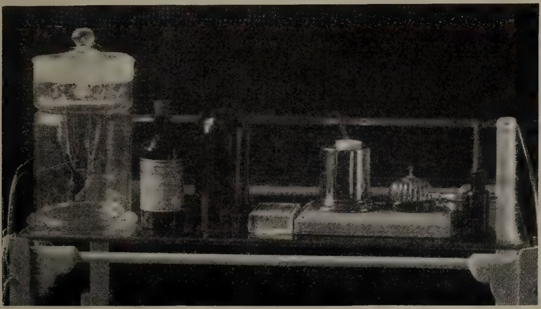

Fig. 1

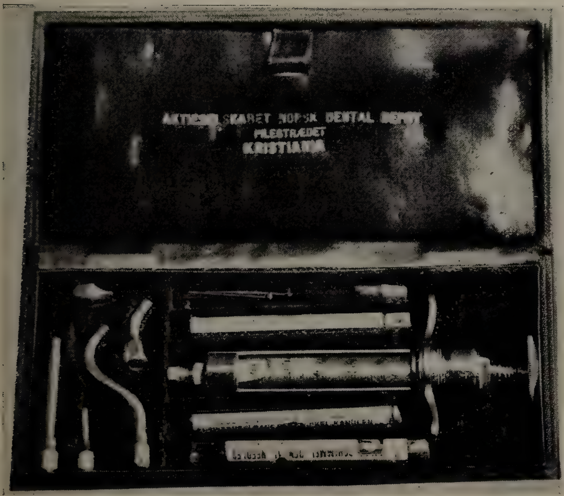

Fig. 2

for the conductive anesthesia, and it is very useful to have at hand in the glass jar two or three syringes with different attachments on and containing about 2 c.c. Before use, the syringe may be rinsed in hot distilled water or you can evaporate the alcohol by carefully drawing the syringe through a flame. Next to the jar (fig. 1) you see the bottle with the Ringer's solution; then the box containing the novocaine capsules and the measuring glass for the novocaine solution. As you see in the picture, this glass is covered with a dark-colored glass cap to keep light and dust away from the solution. By the side of these I have a little electric boiler and the medium dropper for obtaining an exact drop (1 minim) of the suprarenin. The novocaine-suprarenin solution can also be obtained sterilized and ready for use, in small glass tubes; or still better, you may use the novocaine-suprarenin tablets which I suppose have now been perfected to such a degree that you can be sure of always having a fresh sterile solution. The last two methods are, however, more expensive than the first named. I will advise you never to leave bottles with other medicaments on the injection table, so that any dangerous mistakes may be avoided.

To make the injections properly it is necessary to be thoroughly acquainted with the anatomy of the parts concerned so you know exactly where the anesthetic solution should be injected to obtain the best results. By studying skulls you will notice that on the labial portion of the upper and lower jaws there are several small tubular perforations above the apex of the teeth on the fossa mentalis and also in the maxillary process between the teeth. By using the gingival periosteal injection it is then a good practice to direct the injection against those parts of the jaw so that the solution may penetrate or diffuse through the perforations and anesthetize the inner part of the bone, the pulp and the pericementum. In the lower jaws you will notice that these perforations are not so numerous. In certain jaws you will see that there are not so many perforations in the same portions of the jaws. This is due to age and individual differences, and that is the reason why in some cases you will have perfect anesthesia with the mucous injection, while in other cases you will not. In the fossa canina you will notice many perforations but in other cases they are not so frequent. The buccal side of the lower jaw is very compact. With the exception of the foramen mentale and the septum between the teeth there are no perforations.

On the lingual side of the upper jaw are many tubular openings and in the region of the lingual root of the third molar is situated the foramen palatinum anterius. Underneath the papilla incisiva you will find the foramen incisivum. By injection in the region of the first-named foramen and on the maxillary tuberosity you will obtain a conductive anesthesia of the upper molars. The last-named foramen is not often used for injection. On the lingual side of the lower jaw you will not find many openings. The foramen mandibulare is an excellent point for injection to obtain a conductive anesthesia in the lower jaw as far as the molars are concerned. This foramen is found by moving the finger along the line oblique, external and internal to the lingual side of the ramus about one centimeter above the surface of the molars. The other foramen, the mentale, is another point for injection to obtain conductive anesthesia. It is situated in the region of the roots of the bicuspids. The foramen infraorbitale in the upper jaw, found underneath the lower orbital ridge, is very frequently used in conductive anesthesia. An injection here will anesthetize the region of the front teeth, the cuspid and have an uncertain effect on the bicuspids, because there is an anastomosis from the nervi maxillares.

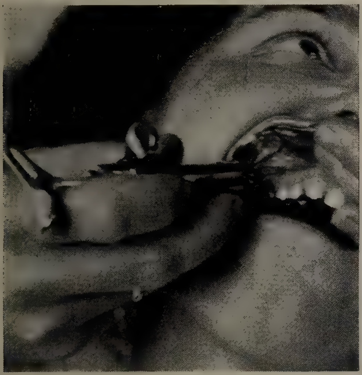

Fig. 3

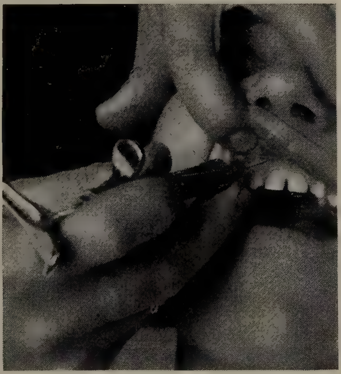

Fig. 4

As a rule we never desire to employ the injection direct to the center of the second and third division of the nervi trigemini. In nearly all cases of operative and oral surgery it will be sufficient to block the nerves far from the center, viz., by the foramen mandibulare and mentale in the lower jaw and the infraorbital foramen, the foramen palatinum anterius and the incisivum and on the maxillary tuberosity in the upper jaw.

The technic of injection for producing local anesthesia in various parts of the oral cavity is shown in the illustrations following: Figure 3 shows the point of insertion of the needle between the upper first and second bicuspids near the apex of the root. Injection here usually anesthetizes the bicuspids and cuspid and occasionally the incisors on the same side. The success of this operation depends largely on the number of foramina in the canine fossa, for it is simply infiltration anesthesia.

Figure 4 shows the point of insertion of the needle in proceeding to anesthetize the incisors on either side by the infiltration method. For conductive anesthesia the needle should puncture the mucosa higher up between the cuspid and lateral incisor above or near the apex of the root (see figure 5). By forcing the solution into the tissues with gentle pressure the area in advance of the point of the needle can be anesthetized and the needle point carried without pain to the region of the infra-orbital foramen.

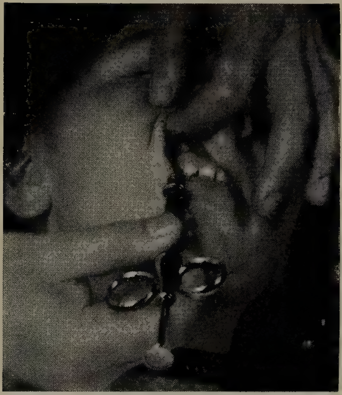

Fig. 5

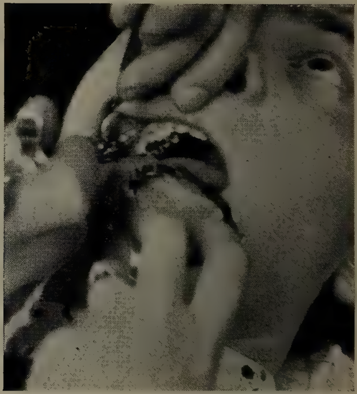

Fig. 6

Slight pressure with the thumb of the left hand (see figure 5) will aid in locating the lower orbital ridge under which, in the center, you have the foramen. With the left forefinger you raise the lip and then force the needle through the tissue up to the region of the foramen, slowly injecting 1 or 2 c.c., employing massage during and after injection. Anesthesia will be produced within about ten minutes after injection, and reach from the median line to the bicuspids. While the thumb is in this position you can usually feel the advancing needle.

Figure 6 shows one of the points of injection on the maxillary tuberosity for the purpose of anesthetizing the molars. The other point of injection is on the palatal surface, and is obtained by using the goose-neck attachment for the syringe, shown in figure 10. Conductive anesthesia is obtained by means of this injection and usually requires from five to fifteen minutes to obtain the desired results. The buccal injection is not so convenient in older patients on account of the presence of the third molars.

Figure 7 illustrates the position of the syringe when injecting with a straight needle in the region of the inferior dental foramen for conductive anesthesia. Figure 8 is a similar demonstration on the mandible itself.

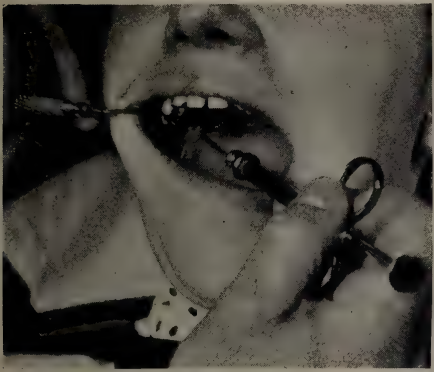

Fig. 7

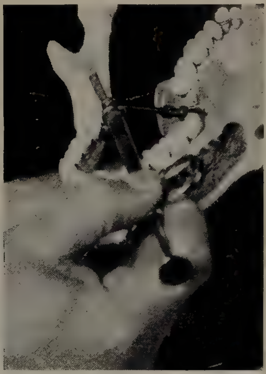

Fig. 8

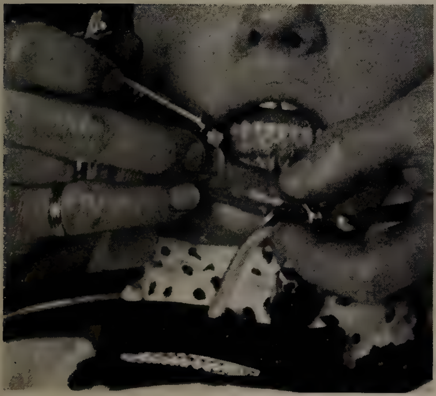

Fig. 9

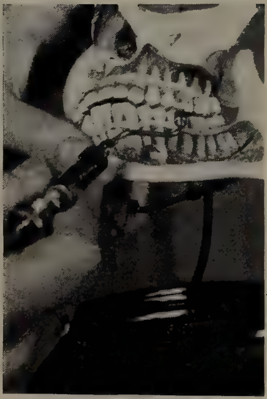

Fig. 10

This same region can be reached conveniently and with less danger or discomfort to the patient by using a goose-neck attachment shown in figure 10, and operating from the same side of the mouth in which the injection is to be made. The lower anterior teeth are anesthetized by the infiltration method in younger patients, as shown in figure 9; where the bone is dense and there are but few foramina it is necessary to resort to the intra-osseous injection, preferably injecting between the cuspid and lateral, on account of the greater divergence of the roots. The technic of this method is familiar to all. However, the point of the insertion of the needle through the buccal plate is shown in figure 10. I usually use a beutelrock drill, of the same diameter as the needle for making the opening through the buccal plate. No pressure is necessary in making this injection, since the solution is forced into the spongiosa and the tissues in that region are not very dense. The right-angle attachment to the syringe is usually advantageous for intra-osseous injection distal to the lower third molars, as shown in figure 11, the opening through the external plate being made by a right-angle drill or round bur.

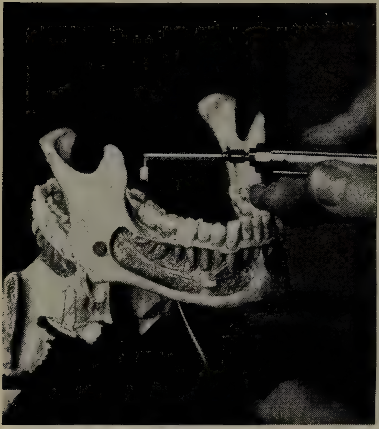

Fig. 11

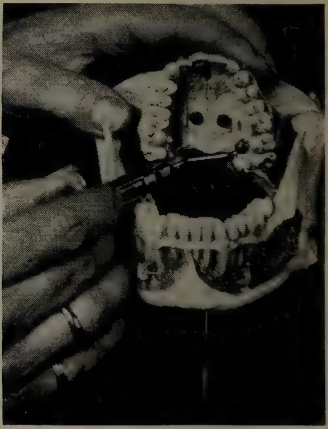

Fig. 12

Figure 12 shows the point of insertion of the needle on the palatal surface of the upper maxilla between the first and second molars for intra-osseous injection, the goose-neck attachment being used.

Various types of retractors used in making operations upon the oral cavity are of value and in certain instances they enable the operator to have the free use of both hands. An especially designed retractor is shown in figure 13, which the assistant can hold, and is an excellent instrument for holding back the periosteum. The opening is shown and there is little danger that the tissue will slip in using this instrument. Note the cotton doilies which are held between the teeth by the patient, acting as a sponge to absorb the blood and mucus, and thus preventing it reaching the throat and stomach. Other types of retractors with the head gear are shown in figures 14 and 15. These are adjustable and very satisfactory. They are applied after the anesthesia is produced and the patient suffers no material inconvenience from them.

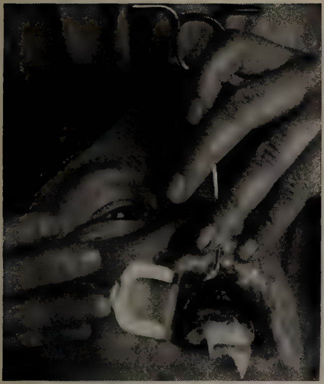

Fig. 13

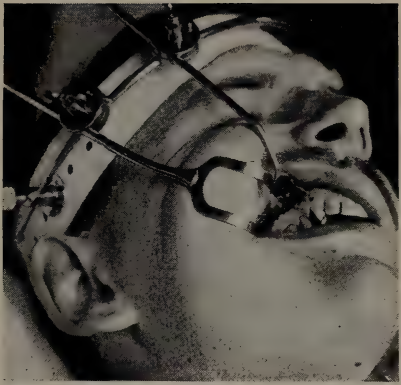

Fig. 14

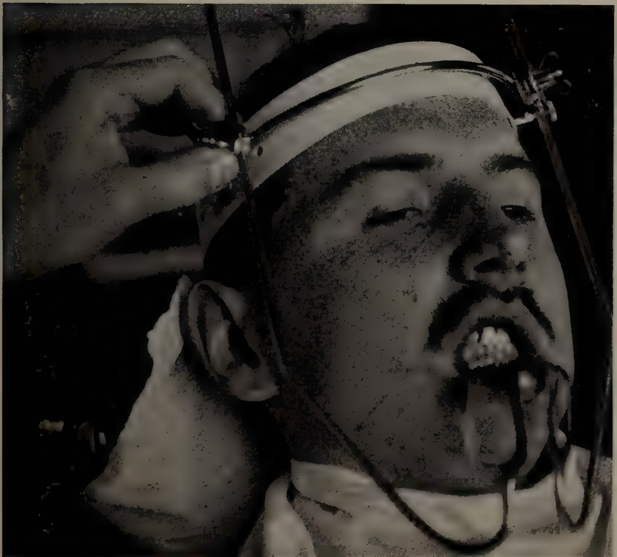

Fig. 15

Technique of Injection—We may divide the technique of injection into four groups.

(1) The total conductive anesthesia.
(2) The partial conductive anesthesia.
(3) The gingival periosteal injection, also called mucous injection.
(4) The intra-alveolar injection.

Before I describe the different methods and the technique I may say a few words about the effect of novocaine-suprarenin injections on the patient with serious constitutional diseases and hysteria. It is certainly our duty before we commence making an injection to make sure of the patient's state of health. In cases of heart-weakness, nephritis, diabetes, arteriosclerosis, we ought to use a weaker solution of the novocaine, 1.5 or 1 per cent, and reduce the addition of suprarenin to about 2 drops to each 5 c.c. Without hesitation we can employ such a weak solution, and there will be no risk of the patient's life.

Doctor Fischer also recommended in those cases the use of a compression bandage around the neck, tightened so that the patient's face becomes a little flushed, thereby slowing the blood circulation, causing absorption of the anesthetic solution and avoiding collapse due to anaemia of the brain. We can also reduce the patient's sensibility by internal administrations of morphine two hours previous to the operation: 6 to 8 drops in a tablespoonful of water.

Formula:

Morphin,	0.20 grams
Hyocin,	0.005 grams
Aqua Dist.,	10.00 c.c.

Sometimes, I find them very rare, you may, after injection on hysterics, observe hallucinations of a sexual nature, so where we have to operate on hysterical patients it is advisable to have a third person present. You may also observe different effects of the anesthetic in those cases. It seems to have an imperfect action or fail and it may also produce a kind of narcotic condition lasting for hours. Without doubt the failures are only apparent ones, and I have noticed that anesthesia was complete despite the patient's misleading gestures and complaints.

The first-named method of injection, the total conductive anesthesia, is not employed in dental surgery, but I will give a short outline of it because I suppose you will be interested to know how far the technique of injection now has developed. It consists in anesthetizing the second and third division of the nervus trigeminus, where they leave the cranial base in the foramen rotundum and ovale. The development of this technique is from Drs. Schlosers, Ostealdt and other experimenters with alcohol injection on patients suffering from trigeminal neuralgia Dr. Braun, one of the foremost men in the field of local anesthesia, remarked the great value of this method and adopted it to include also injections of novocaine-suprarenin solution. The foramen rotundum injection can be performed either in the orbital direction or by introducing the needle underneath the os zygomaticus following the maxillary tuberosity to the fossa pterigo palatina. The injection into the foramen ovale is most trustworthily performed by inserting the needle through the skin underneath the arcus zygomaticus and forcing it gently upward, backward between the tuberosity of the maxilla and the ramus of the lower jaw to the intratemporal and foramen ovale.

The partial conductive anesthesia is of great value in all those cases of dental surgery where inflammations exclude a mucous or intra-alveolar injection. This method of injection will seldom fail when you are acquainted with the technique and is especially suitable in extracting teeth affected with periostitis, surgical treatment of absesses, cysts, empyema of antrum, curetage of extensive areas of necrosis, and other cases of minor surgery.

By the third method (the gingival periosteal or mucous) it is of great importance to insert the needle against those parts of the jaw, where we have the tubular opening in the bone as I have mentioned before. This method is especially indicated in the maxilla as far as the front teeth and bicuspids are concerned, and where we have no inflamation. The cuspid and molars are anesthetized in a more certain manner by the intra-alveolar injection. The puncture is made through the mucosa and underneath the periosteum, and it is very essential to have the flat part of the needle point pressed against the bone. Now, inject the solution very slowly and gently with a steadily increasing pressure and at the same time massage the gum a little with the left forefinger; 1 or 1.5 c.c. will be enough in most cases to obtain anesthesia in the central and lateral incisors about five minutes after injection. When employing the gingival injection for the molars it will generally be necessary to inject also on the lingual side in the region of the apex of the roots. In the lower jaw it will be difficult, especially on adults, to obtain good results by mucous anesthesia because the diffusion of the anesthetic solution is impeded by the thick cortical layer of bone. As far as the front teeth are concerned, you may have good results by injecting in the region of the fossa mentalis, where the outer layer is a little porous.

The other teeth in the lower jaw are best anesthetized by the fourth method of injection, the intra-alveolar. In all cases where there is indication for mucous anesthesia, this method offers great advantages. (1) The effect of the injection is more certain. (2) The quantity of the solution can be reduced. (3) Anesthesia is obtained immediately after injection and is more localized. This method was first used and described by Dr. J. Otte of Holland, in 1896. He advocates the method as very practicable in extraction with the use of cocaine solution. Otte made the perforation into the spongiosa at nearly right angles to the root using a trepan-drill 1 mm. in diameter, after having first obtained anesthesia of the mucous membrane. This method was not very widely employed until later on, when it had been improved and developed in Norway, and at the present time it is not very generally adopted outside of Norway. In Dr. Fisher's book, *Local Anesthesia in Dental Surgery,* a book which I should like to recommend for your perusal, he strangely enough makes no mention of intra-alveolar injection, though he admits that the mucous anesthesia in the mandible is not sufficiently certain, and I find the mandibular injection impractical for obtaining anesthesia in all cases of pulp extractions, excavation of sensitive cavities and also extractions when there is no inflammation present. In those cases it is a waste of time to employ the mandibular anesthesia because you have to wait at least fifteen minutes before the effect of the anesthetic solution is there. As I said, this method is not much adopted and I think it is on account of the fear of infection.

Six years ago I gave a demonstration of this method to a private gathering of dentists in Chicago. They admired the excellent results obtained by the method but nevertheless were inclined to be skeptical as they feared the danger of infection which might give rise to serious forms of periostitis. However, statistics in Norway extending over several thousand cases prove that if the injection is made with scrupulous care and aseptically from beginning to end there will be no risk of infection. The Norwegian improved method is essentially the same as Otte's except that the perforation is made on a level with the neck of the tooth and parallel to the axis. Instead of a trepan drill we use a beutelrock root-canal drill of the same diameter as the needle of the syringe.

When employing intra-alveolar injection you have to take the same precautions as in the other methods. First and last, work aseptically. The syringe, needle, drill and solution must be sterile, and the place for insertion must be thoroughly rubbed with the iodine-aconite solution and kept free from the flow of saliva. After these precautions inject a little into the gingiva, about 2 mm. from the tip of the interdental papilla, wait a few minutes and then bore through the hard outer part of the bone into the spongiosa. Care must be taken to reach the septum between the roots without touching the pericementum. Otherwise there will be soreness of the tooth lasting for several days. Therefore, in carrying out the injection it is necessary to be perfectly acquainted with the position of the roots of the jaw.

Figure 11 shows the lower jaw with the outer part of the bone removed, so that the position of the roots can be clearly seen. You also see where perforation must be made when anesthetizing the wisdom tooth. In this case it will be convenient to use a right-angled attachment to the syringe or you may simply bend the needle into the angle most suitable for the case at hand. Figure 12 shows where to penetrate the bone when anesthetizing the first and second molars. The perforation is nearly always made on the buccal side, but if the crowns of the teeth are inclined outward it is more convenient to operate on the lingual side. Before inserting the needle into the spongiosa it must be sterilized either by drawing it through the flame of a spirit lamp or by leaving it in boiling water between the first and second injections. Then take care that there are no air bubbles in the syringe, insert the needle into the hole and inject about 0.5 c.c. of the solution with a gentle pressure. Maintain the pressure while withdrawing the needle so that the passage becomes filled with the solution, hereby excluding a possible risk of infection through the hole. Such risk, however, should be practically excluded because the contraction of the tissues follows so closely on the withdrawal of the needle as to preclude the possibility of an invasion of microbes. I may also have the pleasure to show a few slides, which better than words will demonstrate a few cases of minor oral surgery very common in our practice. I also hope to have the opportunity to give a series of clinical demonstrations on patients, because you then can make a direct study of the technique of injection, its effects and after-effects.

While thanking you for the patience and attention with which you have followed my remarks, I may express the hope that I have made clear to you the most important consideration in connection with the subject of local anesthesia. My own experience in the field of local anesthesia makes me believe that novocaine is the ideal anesthetic, and if I have succeeded in awakening interest in this important subject among my American colleagues, whose world-wide abilities are so well known, my object will have been attained.

UNIVERSITY OF CALIFORNIA
UNIVERSITY EXTENSION DIVISION
COLLEGE OF DENTISTRY

PROGRAMME

OF

COURSES OF LECTURES AND CLINICS

BY

DR. ARTHUR D. BLACK

CHICAGO, ILL.

DR. JAMES D. MCCOY

LOS ANGELES, CAL.

DR. GEO. L. BEAN

SAN FRANCISCO, CAL.

SAN FRANCISCO, CALIFORNIA
JANUARY 3RD TO JANUARY 7TH, 1916

AT SAN FRANCISCO
UNIVERSITY OF CALIFORNIA
COLLEGE OF DENTISTRY

ARGUELLO B'L'V'D. AND PARNASSUS AVENUE

(Take car No. 6 direct from Ferry)

DR. ARTHUR D. BLACK

MONDAY, JANUARY 3, 1916

9:00 A. M.—Introductory Address.

Lecture.

Histology and physical powers of peridental membrane.

10:30 A. M. to 12:30 P. M.—Clinic demonstration for the entire class.

TUESDAY, JANUARY 4, 1916

9:00 A. M.—Lecture.

Studies of formation of calculus. Inflammation caused by salivary calculus and treatment.

10:30 A. M. to 12:30 P. M.—Clinic period for Section I.

WEDNESDAY, JANUARY 5, 1916

9:00 A. M.—Lecture.

Gingivitis caused by serumal deposits and by injuries to gingivae with treatment.

10:30 A. M. to 12:30 P. M.—Clinic period fo
Section II.

TUESDAY, JANUARY 4, 1916

Sections I and III

1:30 to 4:30 P. M.—Technique period on construction of porcelain shell crowns.

WEDNESDAY, JANUARY 5, 1916

Sections II and IV

1:30 to 4:30 P. M.—Technique period on construction of porcelain shell crowns.

THURSDAY, JANUARY 6, 1916

Sections I and III

1:30 to 4:30 P. M.—Technique period on construction of porcelain shell crowns, etc.

FRIDAY, JANUARY 7, 1916

Sections II and IV

1:30 to 4:30 P. M.—Technique period on construction of porcelain shell crowns, etc.

WEDNESDAY, JANUARY 5, 1916

10:30 A. M. to 12:30 P. M.—X-ray clinic for Section III.

4:30 to 5:30 P. M.—Lecture.
The technique of dental and oral radiography.

THURSDAY, JANUARY 6, 1916

10:30 A. M. to 12:30 P. M.—X-ray clinic for Section IV.

4:30 to 5:30 P. M.—Lecture.
The technique of dental and oral radiography.

FRIDAY, JANUARY 7, 1916

10:30 A. M. to 12:30 P. M.—X-ray clinic for Section I.

4:30 to 5:30 P. M.—Lecture.
Interpretation of radiographs.

DR. GEO. L. BEAN

MONDAY, JANUARY 3, 1916

1:30 P. M.—Lecture.
The technique for hand carved porcelain shell and other crowns, together with amalgam model technique for crowns and inlays.

2:30 to 4:30 P. M.—Technique period for entire class making models and amalgam dies.

THURSDAY, JANUARY 6, 1916

:00 A. M.—Lecture.

Chronic Suppurative Pericementitis and treatment, including oral prophylaxis.

10:30 A. M. to 12:30 P. M.—Clinic period for Section III.

FRIDAY, JANUARY 7, 1916

:00 A. M.—Lecture.

Relation of chronic alveolar abscess and chronic suppurative pericementitis to general health, with suggestions for diagnosis, records, reports to physicians and management of cases.

:30 A. M. to 12:30 P. M.—Clinic period for Section IV.

DR. JAMES D. McCOY

MONDAY, JANUARY 3, 1916

30 to 5:30 P. M.—Lecture.

The nature of the X-ray and the manner of its production.

TUESDAY, JANUARY 4, 1916

:30 A. M. to 12:30 P. M.—X-ray clinic for Section II.

:30 to 5:30 P. M.—Lecture.

X-ray machines and other requisites of the dental X-ray laboratory.

GENERAL INFORMATION

During the course, those members who sire to make a special study of any of courses offered may devote their time to th studies with the understanding that they not infringe upon the rights of the other me bers of the class.

The examination and charting of cases pyorrhœa—the further study of radiogra and of porcelain work may be carried o the infirmary or laboratories.

A dental X-ray equipment will be insta which will be available for use by member the class during the afternoons—the m ings being reserved for Doctor McCoy's cli and an exhibit of radiographic slides wil maintained for interpretative study.

All communications should be directe Dr. Guy S. Millberry, Dean, College of I tistry, University of California, Arguello Parnassus avenues, San Francisco.

Complimentary dinners will be tendered lecturers by the Alameda County Dental ciety at the Hotel Oakland, Wednesday e ing, January 5th, and by the San Franc Dental Society, at the Commercial Club Friday evening, January 7th. Further nouncements will be made later.

UNIVERSITY OF CALIFORNIA
UNIVERSITY EXTENSION DIVISION
COLLEGE OF DENTISTRY

Dear Doctor:

The third annual Institute of the College of Dentistry, University of California, will be held in Los Angeles and San Francisco in December–January, 1915–16. In order to meet the increasing demand for such instruction and give it in a more practical way, a modification of the former procedure has been decided upon and slightly different method of presenting the course adopted.

SUBJECT

The subject selected this year, the pathology and treatment of the pericemental and periapical tissues surrounding the teeth, has commanded the most serious consideration from the medical and dental professions and the laity, and it is hoped that the lectures and clinics presented will enlighten us as to the etiology and treatment of these lesions together with the best modern thought as to prevention.

PERICEMENTAL AND PERIAPICAL LESIONS AND THEIR TREATMENT

Dr. ARTHUR D. BLACK

This subject will be presented in five lectures and five clinics with discussions, by Dr. Arthur D. Black, Professor of Operative Dentistry and Dental Pathology, Northwestern University, Chicago, Ill. During the clinical periods which will be presented to sections, operative procedure in the treatment of pericemental lesions, including pyorrhoea and prophylaxis, will be shown. While this does not permit of individual instruction, yet Doctor Black hopes it may be possible to present the work in a manner which, with discussion at the clinics, will allow each person to become familiar with his technique in performing types of operations that every one is conversant with in his own way. Doctor Black's course will be presented in Los Angeles and San Francisco.

DENTAL RADIOGRAPHY

Dr. JAMES D. McCOY

Present day treatment of these lesions, and particularly alveolar abscesses and their adjacent sequelae, includes a knowledge of radiography, and it has been decided to present this course in a practical way. The subject will be presented in five lectures by Dr. James D. McCoy, Professor of Orthodontia and Radiography, College of Dentistry, University of Southern California, Los Angeles, Calif. In addition to the lectures the class will receive practical instruction in the use of equipment, types of apparatus used in dental practice will be available, with demonstrators, and each member who is sufficiently interested will attend a clinical period, during which time he will be expected to make exposures and develop the same. These clinical periods will alternate with the clinic periods reserved for Doctor Black's work. The leisure time which the members may have during the afternoons can be devoted to a further study if desired. Doctor McCoy's course will be given in San Francisco *only.*

PORCELAIN SHELL CROWNS AND AMALGAM MODEL TECHNIQUE

Dr. GEORGE L. BEAN

This subject will be presented by lectures outlining the principles of porcelain shell crown construction, with their application in dentistry and a general plan of the technical procedure, by Dr. George L. Bean, Professor of Dental Porcelain, College of Dentistry, University of California. The details, however, will be presented step by step in the technical laboratory, where each person attending will be expected to carry out the construction of one anterior and one posterior porcelain shell crown

Barring a lack of experience in carving and shading porcelain crowns, the department offers the assurance that every one who takes the course and follows the technic in detail will be able to make a perfect fitting porcelain shell crown for any case which presents itself in practice.

New methods in the technique of using amalgam models for the laboratory construction of porcelain shell, and all other types of crowns, also complicated gold and porcelain inlays will be shown. The use of a refractory material, new to dentistry, and the manipulation of high fusing porcelain will be prominent features of the course. Doctor Bean's course will be given in San Francisco *only.*

A list of instruments, equipment and supplies which each member must bring with him on the first day, together with such equipment and material as the department will supply is appended.

TIMES AND PLACES

In **Los Angeles** the Institute will convene on **Monday, December 27th,** at the College of Dentistry, University of Southern California, Sixteenth and Los Angeles Streets, and will include Doctor Black's work *only*, which will be given from 9:00 a.m. to 12:30 p.m. The arrangements for the course in Los Angeles are in the hands of Dr. J. S. Montague, Van Nuys Building, Los Angeles, to whom inquiries and subscriptions may be addressed.

In **San Francisco** the Institute will convene on **Monday, January 3rd,** at 9:00 a.m., at the College of Dentistry, University of California, First and Parnassus Avenues.

The schedule will provide lectures by Dr. A. D. BLACK, at 9:00 a.m., for the entire class to be followed with clinics for the sections from 10:30 to 12:30. Members will be entitled to attend one or two clinics, as may be satisfactorily arranged.

The lectures in radiography will be given from 4:30 to 5:30 p.m. each day, with clinics from 10:30 to 12:30 daily, alternating with the periods assigned to Doctor Black.

The lectures and technic periods in porcelain will begin promptly at 1:30 p.m. each day, the entire class appearing for laboratory work on Monday afternoon. If necessary, the class will thereafter be divided into sections for laboratory work. Owing to the limited time available for completing the work to be done by the class, each member will be expected to have his equipment on hand the first period, 1:30 p.m. Monday.

FEES

The fees for the course in Los Angeles will be $5.00 and for the course in San Francisco will be $15.00.

COMMUNICATIONS

All subscriptions for this course should be made payable to the College of Dentistry, University of California, and mailed to Dr. GUY S. MILLBERRY, Dean of the College of Dentistry, First and Parnassus Avenues, San Francisco, or to Dr. JAS. S. MONTAGUE, 916 Van Nuys Building, Los Angeles. All funds received will be deposited with The Regents of the University of California, and used exclusively for Institute purposes.

A program and ticket will be sent to each member of the class in time to arrange for attendance.

Very truly yours,

GUY S. MILLBERRY,
Dean.

NOTE.—Doctor BLACK'S work will also be given in Portland and Seattle.

EQUIPMENT FOR PORCELAIN WORK

TO BE FURNISHED BY INDIVIDUAL

Required list	*Preferred type*
2 platinum foil burnishers	1 Reeve's No. 1 1 Thompson No. 2
1 Brewster sabre point carver	U. C. Special
1 spatula for mixing porcelain	F. W. D. & Co.
1 pinvise	Kendrick & Davis No. 175
1 mixing slab	
2 brushes	1 Windsor & Newton No. 0 round 1 Jenkins No. 4
1 pair furnace tongs or pliers	
1 pipette bottle	
1 bridge impression tray	
2 bridge articulators	
1 pair small scissors	
1 small swaging device with unvulcanized rubber	
1 flat file	
1 plaster bowl and spatula	
1 electric furnace (2 persons can use one furnace, or 4 persons on alternate days.)	
1 dwt. 1/1000 platinum foil.	
1 inch No. 17 gauge round iridio-platinum wire	
1 oz. quick setting amalgam and mercury	
1 jar S. S. W., body No. 3, 2560° F.	
1 jar S. S. W., body No 6, 2560° F.	
1 sheet Detroit Modeling Compound	
1 sheet wax for "bite"	

TO BE FURNISHED BY DEPARTMENT

1 metal model and plaster bite
Plaster of Paris
Varnishes
Copper bands
Emery paper
Refractory cement

UNIVERSITY OF CALIFORNIA
COLLEGE OF DENTISTRY

EXTENSION LECTURES
3

THE DISEASES AND TREATMENT OF THE INVESTING TISSUES OF THE TEETH

BY

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INTRODUCTION*

Before taking up the work for which we are assembled, I wish to express my appreciation of the honor conferred by the University of California in extending to me an invitation to be one of the lecturers of this Institute. I am pleased also to say a few words in commendation of the action of the University of California in adding dental courses to its extension work. It is a compliment to the profession that the importance of our service to humanity is thus recognized, and I trust that these courses will in future years continue to receive the hearty support of the profession. I wish, before this class, to compliment Dean Millberry for having seen the need of courses under University control, by men without the sphere of influence of commercial interests, and for having suggested the plan to the University authorities. Such courses should stimulate the members of the profession to keep closely abreast of the times and improve the general average of dental service. Thus we see that the University of California is promoting a scheme in which the people of the entire State should be interested, for they will in the end be the beneficiaries.

The treatment of disease improves with more complete knowledge of pathology. For each disease, we should be able to apply treatment closer to the source, more directly to the cause, or actually to prevent it, as our understanding of the pathology becomes more perfect. We are all familiar with the gradual advancement in the treatment of typhoid fever, especially in the prevention of it by improved sanitation when the methods of transmission became known, and by vaccination after the effect of the infection in the development of antibodies was understood. The discovery of the role which the mosquito played in the transmission of yellow fever and malaria made it possible for our government to carry to completion the construction of the Panama Canal, the failure of the French attempt having been due principally to the ravages of these diseases.

A careful review of the literature of dentistry reveals little other than very meager statements of the pathology of the diseases of the peridental membrane. The very large majority of writings on this subject concern themselves with names applied by various authors, with theories as to local and systemic causes, and with statements emphasizing the necessity of removing deposits from roots of the teeth. Very few men seem to have made a serious effort to study and present in detail the pathological changes which take place or to differentiate the various diseases to which the investing tissues are subject. It is not surprising, therefore, that the many plans of treatment have generally been unsuccessful. As a basis for the institution of more rational treatment, this course of lectures will be devoted largely to studies of the histology, physical functions and pathological changes in these tissues. After a time we will come to realize that many of us have been endeavoring to accomplish the impossible.

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* This course of lectures follows closely the recently published book *Special Dental Pathology,* by the late Dr. G. V. Black (Medico-Dental Publishing Co., Chicago; Claudius Ash, Sons and Co., London, 1915), credit to which is hereby acknowledged. The illustrations herein were reproduced from the same book, as were about one hundred and fifty stereopticon slides used to illustrate the lectures.

The peridental membrane is defined as the soft tissue which serves to connect the root of the tooth with the bone of the alveolar process. We might refer to it as the connecting link between chronic infection of the mouth and the general health, since there is practically always a break in this tissue which permits the infective agent to enter the circulation and be carried to distant parts. We might also think of this tissue as that which must bind together the medical and dental professions in their fight against the ever-increasing list of diseases which are recognized as occurring secondary to focal infections. We are concerned chiefly with the dentist's part in protecting the health of his patients, but we will not overlook his duty to conserve the teeth.

Disease of the peridental membrane does not occur except as a result of (1) a preceding gingivitis or (2) the death of the dental pulp. In the one case there may occur a detachment of the tissue from the cementum beginning at the gingival line of the tooth, with the formation of a pus pocket alongside the root; in the other, the detachment occurs about the apex of the root with the development of a chronic alveolar abscess. It will be noted later that the pathological changes in both cases are similar and that we are confronted with the same difficulties in protecting the general health from the effects of these foci. We will come to realize also that the danger to health demands the elimination of all such foci.

The chronicity of these diseases has led to much confusion in our ideas and knowledge of the pathology. It is not unusual for cases to run twenty or thirty years before all of the teeth are lost, and few dentists have the opportunity to observe many cases from beginning to end. It is not strange, therefore, that we have failed to associate the early symptoms with those of the well-established lesion. Especially have we failed to recognize the relationship between the apparently harmless gingivitis and the secondary serious and generally incurable pericementitis. We must learn to correlate the clinical pictures presented by many cases in various stages of progress and, from these, make a composite which will give us a better understanding of the progressive changes which occur.

We must differentiate several distinct diseases of the gingivae and peridental membrane as to their causation, pathology, and treatment, and in doing this we must have a new nomenclature. Terms which have been applied to a group of diseases must be dropped and others substituted which designate each condition; for the retention of the general terms serves to continue in our minds the confusion which has prevailed. In order to have a clear understanding of the pathology, we require terms which will separate definitely the inflammations of the gingivae from those of the peridental membrane, for it will be pointed out that we may generally cure the one, and practically never the other. Therefore, successful preventive treatment of diseases of the peridental membrane necessitates a clear understanding of the pathology, a recognition of the early stages, and the institution of treatment while there is opportunity to effect a cure.

FIRST LECTURE

HISTOLOGY AND PHYSICAL FUNCTIONS OF THE INVESTING TISSUES OF THE TEETH

The gums, gingivae, cementum, peridental membrane, and the bone of the alveolar process may all be considered as the investing tissues of the teeth. It is important that we have a clear understanding of the histological structure and physical functions of these tissues, in order that we may appreciate the significance of the pathological changes which occur. This will, in turn, lead to more rational treatment. It is especially desirable that we realize the interdependence of these structures upon each other in the performance of their normal functions.

Gums and Gingivae

The gums and gingivae are made up of a pavement epithelium supported by a base of connective tissue. The epithelium of the gingivae is more dense than that of the gums, the cells being very flat and closely packed together on the surface. They are well supported by many long legs of connective tissues, each of which carries one or more blood vessels far into the epithelial covering. Provision is thus made for the rapid regeneration of the superficial cells, which are frequently injured or worn away as a result of the wear and tear to which they are subjected in mastication. This arrangement also insures prompt healing of injuries to the gingivae and enables this tissue to withstand long-continued or often repeated irritation without serious harm. The gum tissue is a rather insensitive tissue, offering little complaint to injuries which would excite much pain in other tissues. Occasionally, however, long-continued irritation, as the rubbing of the edge of a denture, will develop extreme hypersensitiveness.

It will be noted from the above that one of the important functions of the gingivae is that of protecting the underlying peridental membrane and alveolar process. In fact, this seems to be the principal function of the gingivae. In addition, they doubtless are of material service in maintaining the teeth in the line of the arch.

It is important that we be familiar with the nomenclature of the gingivae and peridental membrane. We may apply the term gingivae to all the soft tissue which rests upon and extends crownwise from the crest of the alveolar process. This may be subdivided into the body, which, encircling each tooth, extends from the crest of the alveolar process to the level of the gingival line of the tooth, the gingival line being the line of junction of cementum and enamel. The free gingivae are those portions which overlie the enamel on the buccal, labial and lingual surfaces of the teeth, and the septal gingivae are the similar portions which occupy the septal or interproximal spaces. We will have occasion to refer frequently to the subgingival spaces—those spaces between the free gingivae and the enamel, or between the septal gingivae

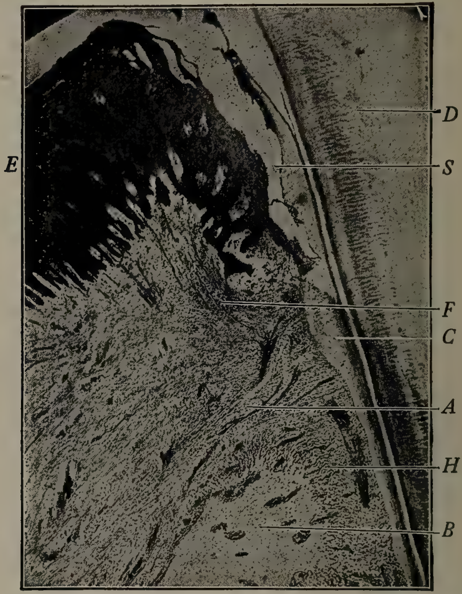

Fig. 1. Longitudinal section through the gingiva and the gingival portion of the peridental membrane, (E) Epithelium. (D) Dentin. (C) Cementum. (S) Subgingival space. (F) Free gingivae group of fibres. (A) Alveolar crest group of fibres. (H) Horizontal group of fibres. (B) Bone of alveolar process.—*Noyes.*

and the enamel. Under normal conditions, a thin, flat blade may be passed into the subgingival space, between the free gingivae and the enamel, until it comes in contact with the attachment of the peridental membrane to the cementum at the gingival line of the tooth.

The gingivae and peridental membrane contain several groups of principal fibres which may be named and briefly described in order, beginning at the gingival line and progressing toward the apex of the root as follows:

The free gingivae group is composed of those fibres which extend outward from the cementum just beyond the gingival line and then turn occlusally into the free gingivae. These fibres help to support the free gingivae and assist in maintaining their close adaptation to the teeth.

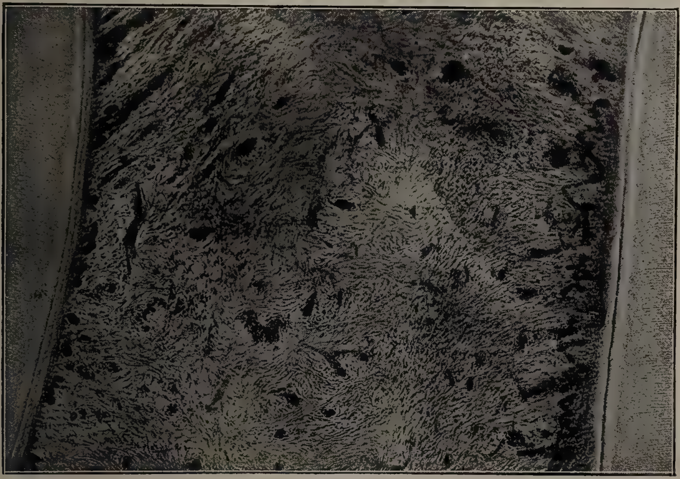

Fig. 2. A portion of the peridental membrane between two incisors of a young sheep, showing the trans-septal fibres extending from tooth to tooth.—*Noyes.*

The trans-septal group consists of a strong band of fibres passing from tooth to tooth through the body of the septal gingivae, occlusally of the crest of the interproximal portion of the alveolar process. The principal function of this group of fibres is to maintain the contacts between the various teeth—to keep the contacts tight. It is necessary to appreciate the function of these fibres in order to understand the movements of of the teeth and the progressive involvement of several proximal surfaces from an original pus pocket on a proximal surface. This will be fully explained later.

The alveolar crest group consists of those fibres which extend outward from the cementum and are attached to the crest of the alveolar process. Their principal function seems to be to steady the tooth against lateral strain.

The horizontal group consists of those fibres which extend outward at right angles to the long axis of the tooth and are attached to the bone of the alveolar process, just below its crest. These fibres act with those of the alveolar crest group in preventing too much lateral movement of the teeth.

The oblique group consists of the fibres which make up the bulk of the peridental membrane. They are attached to the greater part of the surface of the root, and extend in an oblique direction occlusally to the bone of the alveolar process, serving to swing the tooth in its socket and support it against the stress of mastication.

The apical fan-shaped group consists of the many bundles of fibres attached about the apex of the root which radiate in all directions and are attached to the surrounding bone. These fibres tend to maintain the apex of the root in its central position in the socket.

CEMENTUM

The cementum is one of the most important tissues to be considered, for its peculiar structure is in large measure responsible for the chronicity of diseases of the peridental membrane. The cementum is continuous growing, being gradually built by the cementoblasts which lie upon its surface. These cells are to be considered as an integral part of the peridental membrane, as they occupy the space between the fibres and, by their action, build cementum around the fibres, thus attaching them to the root.

Cementum is closely analagous to the subperiosteal bone. It is built by cementoblasts lying on its surface, as is subperiosteal bone by the osteoblasts on its surface. The most important difference is that bone has a circulation of blood within and throughout its structure, while cementum has not. This is a very important fact to remember. When there is a suppurative detachment of the periosteum from bone, the underlying bone dies. Then, as a result of the circulation within the bone, a line of demarkation is established and the dead bone is exfoliated. When the peridental membrane is detached from the cementum by suppuration, the death of the cementum occurs in the same manner, but owing to the lack of circulation within the cementum, the dead portion cannot be thrown off, but remains as a constant irritant to the overlying tissue. This is the principal factor in maintaining the chronicity of the pus pocket alongside the root and the chronic alveolar abscess.

PERIDENTAL MEMBRANE

The peridental membrane contains many specialized elements. The various groups of principal fibres have already been mentioned, as have the cementoblasts and osteoblasts. There are also many strings of epithelial cells which form a more or less definite network about the root of the tooth. The function of these cells has not been definitely determined. Some investigators think they are the remains of those cells which formed the enamel organ and are liable to break down easily as a result of certain toxins in the circulation. Others contend that they have been so placed for the especial purpose of combating infections of the peridental membrane—that they multiply rapidly and accomplish the encystment and destruction of the infective agents and their products. We are inclined to the latter view.

The blood-supply of the peridental membrane is unusually good. Vessels enter about the apex of the tooth and pass alongside the root, other vessels enter over the crest of the bony alveolus, and still others pass directly through the bone. With this triple source of supply the practice of removing the pulps of teeth with the thought of diverting an increase of blood to the peridental membrane would seem to be an unwarranted procedure.

ALVEOLAR PROCESS

The alveolar process is true bone. However, it should be considered an appendage of the tooth. It is built about the tooth as the tooth grows; it disappears following the extraction of the tooth. It seems logical to state that the physiological process of absorption, by which the peridental membrane and alveolar process are removed following the extraction of a tooth, also plays a considerable part in the changes which take place following suppurative detachments of the peridental membrane from the cementum. We should expect the detached fibres, as well as the bone to which their outer ends are attached, to be absorbed, even though they were not involved in the suppuration.

It seems, therefore, that there is a physiological interdependence of the various investing tissues which requires that the health of all be maintained; that serious injury to one is likely to impair them all; and that the gingivae stand guard to protect these underlying tissues. As we study the diseases of these tissues we will come to appreciate more and more the importance of preserving the gingivae in good health in order to prevent disease of the peridental membrane.

SECOND LECTURE

STUDIES OF SALIVARY CALCULUS
INFLAMMATIONS CAUSED BY SALIVARY CALCULUS AND TREATMENT

In view of the fact that the injuries due to deposits of salivary calculus have been recognized since the earliest historical times, it seems strange that so little effort has been made to study the causes and nature of the deposit. Credit is due Dr. Henry H. Buchard for having made the first serious effort in this direction.* Dr. Buchard's theory was based on the fact that water containing carbon dioxide will dissolve a greater quantity of various salts than it will without the gas, and its ability of dissolving these salts is further increased by the addition of more of the gas under pressure. If water is charged with carbon dioxid under pressure in a closed tank, its power of dissolving the salts will be increased in proportion to the quantity of the gas. Then, if the pressure is released, the excess of gas will be given off and the corresponding excess of salts held in solution will be precipitated. In the human body, the fluids are charged with carbon dioxid under the blood pressure, and are therefore capable of holding excessive amounts of calcium and other salts in solution. When the fluids are discharged (as the flowing of the saliva from Stenson's duct), they are released from the blood pressure, and the excess of carbon dioxid escapes, while a due proportion of salts is precipitated. It was reasoned that in the mouth this precipitate would be caught in a curd formed by the action of lactic acid on the mucus, the lactic acid being formed by micro-organisms normal to the mouth, and the precipitated salts and the curd would settle down in out-of-the way places and by additions would finally form a hard mass of calculus.

It was not easy to prove this theory. Dr. Burchard, in his experiments, found that saliva collected in a test-tube, and allowed to stand, would be cloudy within twenty-four hours and it was thought that this cloud was the precipitate of calcium salts.

This was the generally accepted theory until Dr. G. V. Black undertook his long series of experiments about seven years ago. He first duplicated Dr Burchard's experiments with the same results. It then occurred to him that it was not proven that the cloud in the test-tube was calcium salts. He contrived to centrifuge the contents of the tube, collecting it on a microscopic cover-glass held in the bottom of the tube, and found that the cloud was composed entirely of a growth of microorganisms.

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* *Dental Cosmos*, vol. 37, 1895, p. 821.

Many new lines of investigations were then taken up. Our time is too limited to do more than recite certain of the more important findings. Systematic examinations were made of artificial dentures and it was noted that the mucus, which gives a denture a greasy feeling, could be readily washed off with the water running from the hydrant, but that there would frequently remain a new soft deposit of calculus. It was observed that this could be easily removed with a brush and plain water if this was done before the deposit had remained as long as fifteen or twenty hours, but that it was difficult or sometimes impossible to remove the deposit with the brush if it remained twenty-four hours. This, of itself, offers a most practical suggestion for the prevention of the accumulation of these deposits on the teeth by thorough brushing twice daily.

An upper denture was then constructed with a little rectangular gold frame attached to the vulcanite above the buccal surfaces of the molars. This frame was held in place by two screws and was so arranged that a specially ground cover-glass was held under the frame and could be removed and carried to the microscope for examination without disturbing whatever might be collected upon it. It was thus possible to secure and examine deposits in all stages, from the very fresh soft deposits to those which were quite hard. Various staining methods were employed to bring out more clearly the structural characteristics. It was also possible to make photomicrographs of all specimens.

This line of investigation developed several important facts. It was quickly recognized that the deposit was not a precipitate, as had been supposed, but that the forms were all spherical, and the material constituting the deposit was a calco-globulin, and this globulin brings with it the calcium elements which eventually, with the decomposition of the globulin, form the hard deposits. This globulin is called the agglutinin of salivary calculus. Repeated examinations showed the primary deposit to consist of minute spherules (smaller than red blood corpucles) which gradually coalesced to form larger massses of more or less rounded forms.

It was also determined that the outpouring of the deposit is decidedly paroxysmal; this is one of the striking characteristics. It was later discovered that the paroxysms are of comparatively short duration and occur within a few hours after a heavy meal. If, for example, a heavy meal were eaten at noon, the cover-glass on the denture would remain clear until possibly two o'clock, when the paroxysm of deposit would begin. It would continue for an hour and a half or two hours and then cease. A new glass placed at this time would remain clear.

These experiments seem to have established the fact that a heavy meal, especially when well digested, puts into the system more of nutrient material than is required, and that a proper balance is restored by the paroxysmal outpouring of the calco-globulin with all the secretions and excretions, each of the body juices and fluids having its due proportion. Persons subject to frequent heavy deposits were able to continue for weeks without any deposits when they reduced the amount of food taken a little below that to which they were accustomed. During such a period, a single heavy meal would result in a paroxysm of deposit. It seems to make no difference what foods are selected for the heavy meal.

Many other experiments were performed which can not be enumerated in this course. One other thing should be mentioned—a special grinding machine was constructed and a technic developed by which very thin sections of the hard salivary and serumal deposits could be ground thin enough to be available for microscopic study and photographing. These showed the structure of the hard deposits to be similar to the soft deposits caught on the cover-glasses.

INFLAMMATIONS DUE TO DEPOSITS OF SALIVARY CALCULUS

Deposits of calculus always occur on hard substances. In the mouth we find these deposits on the teeth, and on crowns, bridges, artificial dentures, and other appliances. The position of the deposit is most likely to be near the orifices of the ducts from the salivary glands; upon the buccal surfaces of the molars and the lingual surfaces of the lower incisors. The initial deposit is usually at the position of the crest of the free gingivae and occurs because there has been a slight blunting of the normally thin edge. Such a blunting, or some irregularity of form, seems necessary for the initial deposits to become attached. This fact should emphasize the importance of keeping the gingivae in good health with normal thin crests.

Gingivitis Caused by Deposits of Salivary Calculus

When the initial deposit in any position has become hard, there is an irritation of the underlying gingivae. This form of gingivitis, with the gradual accumulation of the deposit, is distinct from others. There are frequent suppurations of the shelf of gingivae which is in contact with the deposit. As the deposit increases, it gradually destroys the gingivae and is apt to replace in contour the lost tissue. The most striking feature of this, in comparison with certain other forms of gingivitis, is that there is little tendency for the inflammation to involve any other tissue than that of the shelf which is in contact with the deposit.

Pericementis Caused by Deposits of Salivary Calculus

If the deposit is not removed, it is likely to destroy all the gingivae and encroach upon the peridental membrane, gradually destroying not only the peridental membrane, but also the bone of the alveolar process and overlying gum tissue. In all of this there is the tendency for the attachment of fibres of the peridental membrane to be maintained to the level of the tissue destroyed by the deposit. There is little tendency to the stripping off of the peridental membrane from the cementum and the formation of pus pockets alongside the roots. Deposits of salivary calculus should not therefore be considered a cause of pus pocket formation, as has commonly been thought.

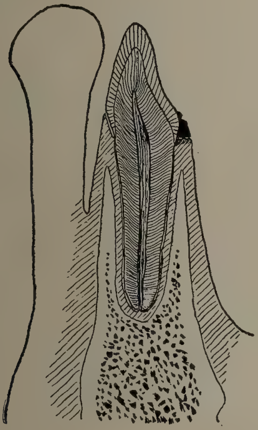


Fig. 3

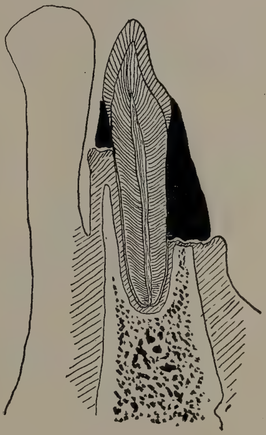


Fig. 4

Fig. 3. Drawing illustrating a slight deposit on the lingual surface of a lower incisor which has caused a gingivitis only, not having progressed far enough to involve the attachment of the peridental membrane to the cementum.

Fig. 4. Drawing illustrating a still greater destruction, including also the labial tissues.

As the destruction of the investing tissues continues, the patient may complain of occasional pain and soreness and the teeth may gradually become loose, so that eventually they are lost. This is a slow process, usually extending over many years, and as suppurations are frequent, the menace to the health is probably greater than has been realized. The thin-walled blood vessels in the granulating surfaces offer micro-organisms easy access to the blood stream.

TREATMENT

The treatment of the inflammations caused by deposits of salivary calculus should always be undertaken with the possibilities of prevention well in mind. It has been stated that fresh deposits are so soft for fifteen or twenty hours that they may be easily removed with a brush and plain water. Therefore, every patient who may be induced to brush the teeth thoroughly twice every day can prevent the inflammation and destruction caused by the hard deposit. This has been sufficiently well demonstrated in many cases to leave no room for doubt of its efficacy.

Our management of cases presenting with deposits should be with the view of gaining the co-operation of the patient to the end that future deposits will be prevented. The removal of the deposits is not difficult. They are practically always in sight; not covered by the gingivae. Only a few simple instruments are required. After the removal of the deposits, the surfaces of the teeth should be polished. If there is much inflammation, frequent rinsing of the mouth with warm salt solution will keep the field clear and lessen the patient's discomfort.

In such cases it is usually best not to advise the patient as to the technic of proper mouth hygiene at the time when the deposits are removed. This should be reserved until the inflammation has subsided. The patient should be given another appointment and should then receive whatever instruction seems necessary to gain his interest and co-operation. This should include a few brief statements explaining the nature of the fresh deposit and the possibility of preventing its accumulation by faithful brushing twice daily. It should also include mention of the danger to the general health, as well as the probable eventual loss of the teeth. Brushes should be selected, their movements demonstrated and instructions given to the finest detail.

If posssible, a definite arrangement should be made for a subsequent examination, so that we may know how well the home care is progressing. A chart of the mouth, showing locations of deposits, should have been made at the time of examination and each position should be carefully inspected. deposits removed if there are any, and additional instruction given the patient. Considerable diplomacy is necessary in the management of many patients, but one who comes to realize fully the effectiveness of this plan is sure to become more and more enthusiastic and more successful in gaining and holding the interest and co-operation of the patients.

THIRD LECTURE

GINGIVITIS CAUSED BY DEPOSITS OF SERUMAL CALCULUS WITH TREATMENT

In considering the inflammations of the gingivae caused by deposits of serumal calculus, we have to do only with the deposits which occur on the enamel of the subgingival spaces. A serum is normally poured out into these spaces to keep them moist. We should expect this serum to contain its proportionate share of calco-globulin, whenever there is a paroxysm. As the quantity of serum is small compared with the amount of the saliva, so will the deposits be small and slow of formation. The causes are the same, and the nature of the deposit is the same as salivary calculus. We will often find both deposits in the same mouth. However, proper care or vigorous mastication may prevent the accumulation of salivary deposits, while serumal deposits are being laid down.

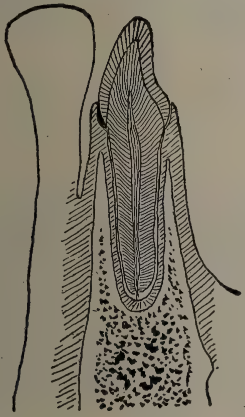


Fig. 5.

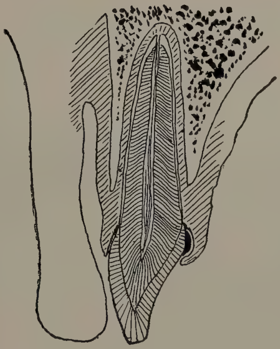


Fig. 6.

Fig. 5. Drawing illustrating a deposit of serumal calculus under the free gingiva on the labial surface of the enamel of a lower incisor tooth.

Fig. 6. Drawing illustrating a similar deposit on the lingual surface of an upper incisor. Suppuration of the peridental membrane, resulting from deposits in this position, causes the teeth to move labially, and such cases are generally hopeless, after much progress has been made.

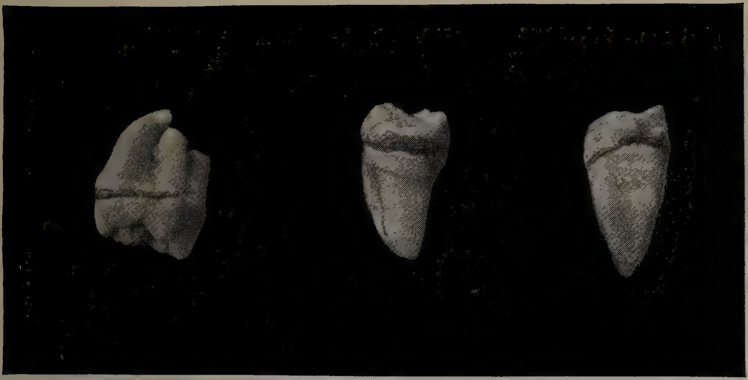
Owing to the fact that the gingivae naturally hug closely about the teeth, the deposits occurring in the subgingival spaces are likely to be compressed while soft, and harden as flattened scales. If the close adaptation of the gingivae is lost as a result of inflammation or detachment of the peridental membrane, the form of the deposit will generally be nodular instead of flat.

Clinically, these deposits may be divided into two groups: one in which there is a general deposit in the subgingival spaces in the form of narrow bands more or less completely encircling the teeth. The inflammation of the overlying gingivae may or may not be apparent. In such mouths deposits of salivary calculus are usually present. In the other group, the deposits will be confined to certain teeth, others being free. In such cases an inflammation of the gingivae about the particular teeth has usually preceded the occurrence of the deposit. An irritation, such as the wedging of food through an open contact, or an ill-fitting crown, causes the outpouring of greatly increased amounts of serum from the inflamed gingivae, thus delivering to these spaces a correspondingly increased amount of calco-globulin for deposit. We therefore find considerable deposits in such locations, with little or none elsewhere in the mouth. It is not uncommon to find deposits on the lingual surfaces of the upper incisors, from the irritation caused by food forced against the gingivae by the lower incisors, especially if there is much overbite.

In all cases in which there are deposits of serumal calculus in the subgingival spaces, these cause inflammation of the overlying gingivae, and occasionally suppuration occurs. The tissues may recover without serious harm having been done. Sooner or later, however, a suppuration will involve the attachment of the peridental membrane at the gingival line and a little pus pocket will be formed. In this way these deposits become the real exciting cause of suppurative detachments of the peridental membrane in probably twenty per cent of cases.

TREATMENT

The treatment of inflammations caused by these deposits should be along the same general lines as that mentioned for salivary deposits. More delicate instruments are required, also a higher degree of finger skill. One must learn to feel the deposits and to recognize a surface free of deposit in positions where he cannot see. While proper brushing by the patient will assist in keeping the gingivae in good health, the use of a rubber bulb syringe to wash out the subgingival spaces thoroughly twice a day is much more efficacious. This requires more careful training and instruction and more of enthusiasm to get patients keyed up to the point at which their interest and care will be maintained. A similar plan of recording positions of deposit, of subsequent examinations, etc., should be followed. Even in mouths free from these deposits, nothing



Figs. 7, 8, 9. Three molar teeth showing "rings" of deposits of serumal calculus on the enamel of the subgingival space. Frequently these "rings" encircle the crown. Specimens from Northwestern University Dental Museum.

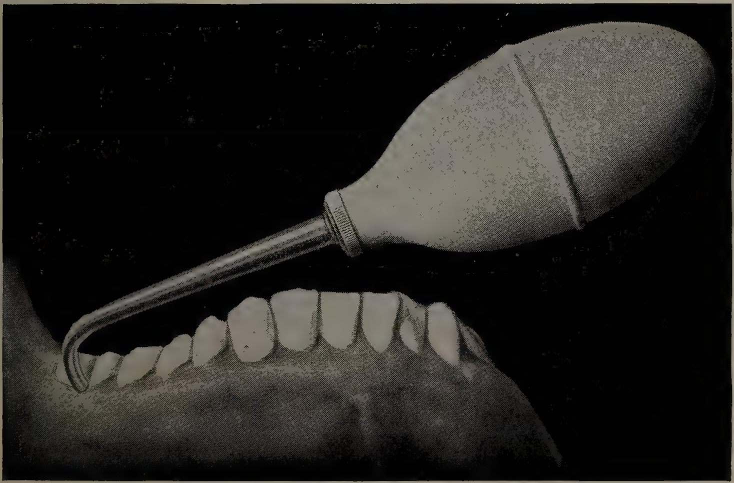
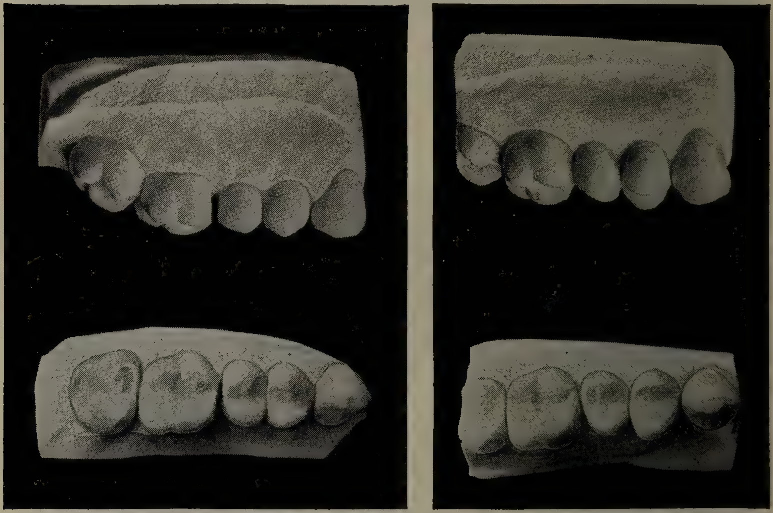


Fig. 10. The position of the rubber bulb syringe in washing the subgingival spaces or pus pockets. The end of the nozzle should touch the enamel of the tooth near the crest of the gingivae as it is passed along the arch, the angle being such that the water or solution will be forced into the subgingival spaces. This is the most effective means of preventing deposits of serumal calculus.

will contribute so greatly to the maintenance of the gingivae in good health as the twice daily irrigation of the subgingival spaces with warm water or normal salt solution.

GINGIVITIS CAUSED BY INJURIES, WITH TREATMENT

In our studies of the histology and physical powers of the investing tissues, the protective function of the gingivae was noted. The gingivae are naturally equipped to withstand severe punishment, which they do in a remarkable way. The fact that they will maintain themselves so long under continued irritation, together with our failure to recognize these injuries as forerunners of more serious lesions of the peridental



Figs. 11, 12. Photographs of plaster models of a case before and after contact restoration. The patient presented with a slight pocket on the mesial surface of the root of the first molar on account of the open contact. The mesial surface of the first molar and distal of the second bicuspid were free from decay and had not been filled. The separation had occurred as a result of flat fillings in the mesial of the second bicuspid and distal of the first bicuspid. These fillings were removed, and a Perry separator was applied on several occasions to move the second bicuspid back into contact with the first molar, it being held there for a time with fillings of base-plate gutta-percha. Later, permanent fillings were made, restoring normal conditions, as shown in Fig. 12. It was necessary to relieve the occlusion on the distal slopes of the cusps of the second bicuspid as it was moved.

membrane, has led to much abuse and neglect. Yet it seems fair to state, from statistics which will be presented, that possibly seventy-five per cent of the pus pockets alongside roots of the teeth are the direct result of long-continued and neglected injuries to the gingivae.

With an irritation of the gingivae from any form of injury, there is opportunity for suppuration, with subsequent involvement of the attachment of the peridental membrane. As has been mentioned, the irritation is likely to result in a deposit of serumal calculus, which becomes a secondary cause of the further progress of the case. In connection with the more acute suppurations there is often considerable pain. Absorptions of the gingivae occur as a result of the constant irritations and repeated suppurations.

It would be almost impossible to cite all the causes of these injuries. Lack of contact of the teeth due to extractions of neighboring teeth, flat fillings, crowns, etc., improper contact of teeth, irregularities of contour due to sharp edges of cavities, bad margins of fillings and crowns, etc., abuse of these tissues in operations, and injuries by patients in cleaning, are the most frequent causes.

In cases in which contacts are not normal, and food is wedged between the teeth, the septal gingivae become inflamed from the repeated impactions of food, also from the efforts to remove it. These impactions will, after a time, result in the absorption of the central portion of the septal tissue, while the buccal and lingual portions may be pushed outward in their respective embrasures. Their appearance is that of slightly swollen festoons. Later on, as the central portion is further depressed, there is likely to be some absorption of the buccal and lingual portions also. This may continue until the absorption has included much of the bone of the alveolar septum, with deep pus pockets on the proximal surfaces of the teeth.

Some patients will complain bitterly of the pain caused by slight impactions of food, others will seem unconscious of the presence of considerable accumulations in many spaces. Treatment should therefore be undertaken on the basis of the impaction and inflammation, rather than on the complaint of the patient.

Several years ago, in order to get some reasonably reliable data as to the frequency of the various forms of gingivitis, I requested a number of dentists in various sections of the country to assist me in collecting certain statistics. I sent a number of examination cards to each man with a request that he make a careful record of the areas of gingivitis found in the mouths of young adults, who had no disease of the peridental membrane. I present herewith a brief summary of the results of the examination of 500 mouths of persons between twenty and thirty-five years of age.

Of the 500 mouths examined, but 25 were reported as having no gingivitis. For the other 475 persons, 4265 areas of gingivitis were reported—an average of 8.53 areas per person for the entire 500. Of these areas, 1348 were due to deposits of salivary calculus. These were in the mouths of 39 per cent of persons examined, and represent 31 per cent of all areas of gingivitis. In recording these, each surface of each tooth having a deposit was counted as one area. For example, a deposit on the lingual surface of the lower incisors and cuspids was counted as six areas.

Five hundred and sixty-three areas were reported as having deposits of serumal calculus on the enamel of the subgingival spaces. These were in the mouths of 15 per cent of persons examined, and represent 13 per cent of all areas of gingivitis. Many who had deposits of salivary calculus also had serumal deposits; 140 persons were reported as having either or both, leaving 360 without deposits of either kind.

There were 2364 areas due to other causes than deposits. Of these, 783 were due to bad margins of fillings or crowns, 496 to lack of contact of fillings or crowns, 305 to improper contact of fillings or crowns, 263 to malpositions or atypical forms of proximal surfaces, 255 to lack of contact with no decay of proximal surfaces, 233 to caries, and 19 to worn contacts.

If we add together the number of areas due to bad margins, lack of contact or improper contact of fillings or crowns, the total is 1584. This number of areas, 37 per cent of all, may be properly charged to imperfect dental operations. This is an average of more than three such areas per mouth, and would seem to indicate that fully one-third of the pus pockets are due to lack of care in operative and prosthetic service.

There was a time when no consideration whatever was given to the soft tissues in the performance of either filling or crowning operations. When files were used to separate the teeth, and wedges were driven between them, the importance of preserving the investing tissues could not have been appreciated. It has only been within comparatively recent years that the attitude of the profession has begun to change. Not until we realize the direct relationship of these areas of gingivitis to the more serious detachments of the peridental membrane which follow, will we be as careful as we should be in the finer technic of all operations so that the number of these injuries will be reduced to the minimum.

Treatment

In the treatment of cases of this kind, it is essential that we should first make careful search for the cause. When this has been found, the treatment will be indicated. If, because of an open contact, food is wedging between the teeth and injuring the septal gingivae, we must, if possible, learn the cause of the open contact. It may be that the cusp of a tooth in the opposite arch needs a little grinding, or the extraction of a tooth may have permitted movement of others, opening the contacts. Many times it is a flat filling which did not restore contact, or it may be any one of many things. Most of these are easily corrected and the gingivitis will promptly subside when the cause of the irritation is eliminated. It is not so much the difficulty of correcting these conditions, as it is the necessity of appreciating the importance of it.

When a contact is too broad, though tight, it should be corrected by trimming to proper form. Other things should be done as required in particular cases. Many require careful study. Close attention to these things will impress the possibilities of prevention by greater care in every operation performed.

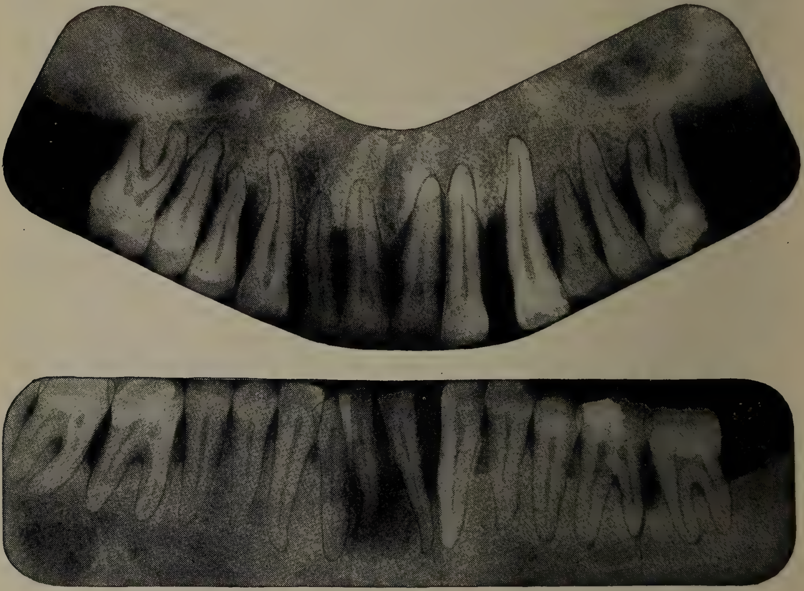
In all of the operations for contact restoration, one of the most important things is proper separation of the teeth without pain or injury to the soft tissues. Notwithstanding all of the more recent devices, I know of nothing so satisfactory as the Perry separators. These seem to meet every requirement. A little experience is necessary to be able to adjust them properly, and they are more expensive than other devices, yet in the long run they are very economical, when one considers the time saved and the benefits gained by their use.

FOURTH LECTURE

CHRONIC SUPPURATIVE PERICEMENTITIS

The term "chronic suppurative pericementitis" is applied to that disease, the essential characteristic of which is the formation of a pus pocket alongside the root of a tooth. This term was selected because it is closely descriptive of the condition. One of the marked features of this disease is its chronicity, to which reference has already been made. It is also essentially a suppurative disease and it is notable that the suppurative process strips the soft tissue from the cementum, which makes the word *pericementitis* especially applicable. There is room for question in many cases, whether or not the bone of the alveolar process is involved directly by the suppuration, or is absorbed secondarily by purely physiological processes. Therefore, terms which indicate an inflammation of the alveolar process do not place the principal tissue involvement where it really occurs. Whether this term, or some other, comes to be finally accepted and used, it is imperative that a name be found which will apply to this condition as a pathologic process different from the others to which the investing tissues are subject.

The local causes leading to the formation of pus pockets have been reviewed. We have said that a gingivitis always precedes the pericementitis, and have emphasized the fact that deposits of serumal calculus and injuries to the gingivae are the principal local exciting causes. In doing this we do not overlook the effect of the systemic condition in some cases in which local causes are found, and we also appreciate the fact that there are cases in which no local causes are apparent. We are, however, most concerned at this time with conditions which are recognizable and for which definite treatment is indicated.



Figs. 13, 14. Panoramic radiographic views of the upper and lower jaws in a case of chronic suppurative pericementitis of long standing. This patient had suffered from gout for five years. The right foot was first swollen and was very painful. In subsequent attacks the ankle was involved. The patient stated that except for this, he had never been sick a day. One lower incisor had become so loose that it was removed with the fingers. Pressure upon the gums caused pus to exude about the necks of many of the teeth. It was advised that all of the teeth be extracted.

Many men have searched for a specific organism which might be proven to be the cause of these suppurations. Up to the present time, all such attempts have failed. Careful clinical study of the progress of cases contraindicates a specific type of infection, as will be explained later.

The recent claim of a number of writers that the endameba is the cause of this disease seems not to be well founded, and the use of emetine has proven a disappointment. It would have been just as logical to select

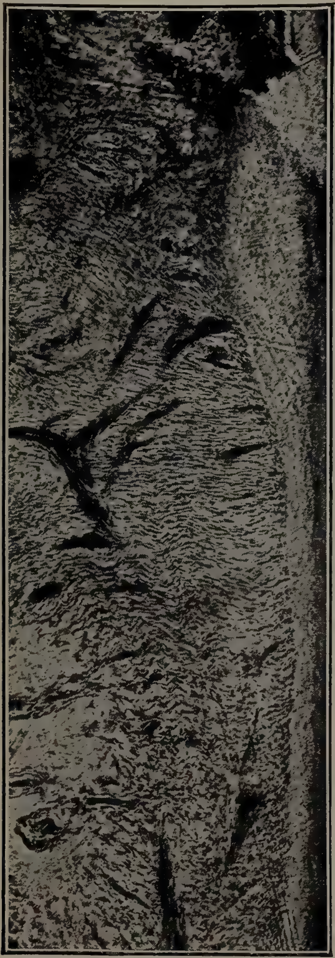


Fig. 15. Normal peridental membrane. The row of cementoblasts may be seen lying along the surface of the cementum. These cells occupy most of the space between the fibers as the latter enter the cementum. Photograph by Dr. F. B. Noyes.

any one of the other organisms which can be generally found in these pockets, and state that it alone caused this disease.

The symptoms and tissue changes are those of a progressive chronic infection. The appearance of the gingivae may be normal, or the crests may be slightly blunted and swollen, with slight or considerable discoloration. The suppuration occurring because of the inflammation of the gingivae sooner or later involves the peridental membrane and cuts it away from the cementum, beginning at the gingival line. When a detachment has been affected, the general tendency is for pockets to slowly progress. This progress is greatest toward the apex of the root, rather than around the root, so that it is not unusual to find very deep, narrow pockets. The cementoblasts are the first of the specialized elements to be destroyed. This seems to occur as a part of the suppurative detachment of the soft tissue from the root. Subsequently, the principal fibres of the peridental membrane gradually disappear from the overlying tissue, and later the bone of the alveolar process to which these fibres were attached disappears also. As has been mentioned, it should be expected

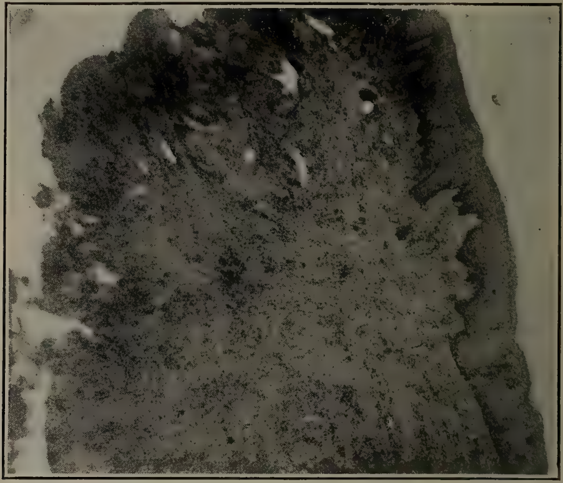


Fig. 16. Section through soft tissue overlying a deep pocket of many years' standing on the labial side of the root of a lower left cuspid; from about the middle of the length of the root. Patient sixty-five years of age. Tissue cut away by Dr. Arthur D. Black on September 29, 1913. Normally the crest of the alveolar process should be present in a section cut in this position. The bone has all disappeared, as have practically all of the fibers of the peridental membrane. Section prepared by Dr. H. A. Potts, photographed by Dr. F. B. Noyes.

that these tissues would be absorbed following the detachment, regardless of their possible involvement in the suppurative process. The disappearance of the fibres of the peridental membrane may be shown by microscopical examination of tissue cut from these positions; while the absorption of the alveolar process is clearly shown by radiographs.

The soft tissue overlying the denuded cementum presents a granulating surface containing many newly formed, thin-walled blood vessels, which offer favorable opportunity for the many micro-organisms within the mouth to enter the circulation. The cementum itself has necessarily absorbed the products of suppuration and putrefaction, so that a condition could hardly be imagined which would present greater difficulties to a normal re-attachment of the tissue to the root. Every specialized element of the peridental membrane has disappeared, and the tissue which remains lies against a cementum which has been rendered negatively chemotactic by absorbing the products of the suppuration. It is for this reason that these detachments are permanent detachments.

It has been suggested that the outer surface of the cementum should be cut away, with the expectation that an attachment would occur similar to that which takes place when teeth are implanted, transplanted or replanted. We have not time to discuss this point at length at this time, but attention is called to the fact that the attachment in such cases is an unstable one, and it in no sense a re-attachment of the peridental membrane. Where such teeth become firm, the rule is that it is by absorption of the root and building in of the surrounding tissue, a process which, within a few years, results in the loss of the tooth.

Doubtless many conscientious operators have been misled into believing that re-attachment occurs; this has resulted from their failure to observe cases with sufficient care over a long enough period of time. It is the rule that many cases look very much better following treatment, and that there is close adaptation of the soft tissue to the root, so that one may be deceived. If such cases are kept under close observation, it will be found practically always that the pockets are still there, and that there will be a recurrence of the pus formation.

Pain is not a prominent symptom, although the tissues about such teeth will occasionally be very painful when the suppurations are acute, or if the pus penetrates deeply into the surrounding tissues. Most patients will complain that the teeth are periodically sore and that they are raised in their sockets. The greater the progress of the case, the more frequently will pain and soreness be noted.

Deposits of serumal calculus will be found upon the denuded cementum in many cases. These deposits should never be considered a cause, but always a result of the formation of the pocket, as the material for the deposit—the calco-globulin—is brought to the pocket by the serum escaping from the overlying inflamed tissue. These deposits are frequently nodular, as the overlying tissue does not hug closely about the root, and the deposit is not compressed while soft, as is often the case with the deposit on the enamel. When deposits have occurred on the cementum, they cause additional inflammation of the overlying tissue and in this way contribute to the further progress of the pocket.

The cervical lymphatic glands are occasionally enlarged in advanced cases. There is also, as a rule, an excitation of the salivary glands, requiring the patient to swallow frequently and possibly to drool at night.

Pus pockets may be divided into two groups, according to their location. In many cases the pockets will all be on proximal surfaces, with little or no involvement of buccal, labial or lingual surfaces. In others, all the pockets will be on buccal, labial or lingual surfaces. In the later stages, all surfaces will be involved. It is not uncommon to find a single pocket on the labial or buccal surface, or possibly two or three. The lingual surfaces of the upper incisors are frequently involved as a group.

The tendency is for teeth having pus pockets on one side to move in the direction away from the pocket. This is partly due to the inflammation, but principally to the fact that the balance of pull of the various fibres of the peridental membrane has been disturbed and the fibres on the sound side pull the tooth in that direction. When the pockets are on the lingual side of the upper incisors, these teeth generally move labially and, with the pull of the trans-septal fibres, soon draw the cuspids away from the first bicuspids and open the contacts. The contacts between the incisors and cuspids are also opened by the forward movement, and the septal tissues soon become inflamed from food impactions. When the labial movement of the incisors has once fairly begun, it is seldom checked and after a time the teeth are lost. Very often the forward movement of the cuspids results in the eventual loss of the bicuspids and molars also.

In cases in which the original pocket is alongside a proximal surface in the bicuspid or molar region, the neighboring teeth are likely to become similarly involved on their proximal surfaces, the buccal and lingual tissues remaining intact. When such a pocket occurs, the inflammation within the septal space, together with the pull of the fibres on the opposite sides of both teeth, tend to open the contact between the teeth. When this occurs, there is usually some pressure on next neighboring contacts, with slight movement of the adjacent teeth. With the subsidence of the inflammation, the teeth return to their normal positions. This is repeated again and again, until after a time the frequent movement results in the weakening of neighboring contacts and stringy foods are forced through, causing inflammation of the septal tissues. This continues until pus pockets are formed on the proximal surfaces of these teeth. In this slow way these cases progress. The movement of the teeth of one arch will often disturb those of the opposite arch and similar inflammations will follow. Thus all the teeth may be lost as a result of a single proximal pus pocket.

Occasionally the pus formed in deep pockets is not discharged alongside the root, but involves the adjacent soft tissues and forms an acute abscess at the side of the root. This is a lateral abscess. It may be mistaken for a true alveolar abscess.

TREATMENT

The key to the treatment of chronic suppurative pericementitis is in the statement that suppurative detachments of the peridental membrane are permanent detachments. With this in mind, we may divide the treatment under three headings: preventive, palliative and radical.

Preventive treatment consists of the carrying out in pactice of every measure which will prevent or cure gingivitis and thus protect the peridental membrane. The methods of doing this have already been discussed. This treatment must be by the general practitioner of dentistry and not by a specialist, for it must come to be a part of every dental operation to conserve the health of the investing tissues. This must be done by careful systematic examinations, properly recorded; by the maintenance of good contacts to promote thorough mastication, and careful training of patients in mouth hygiene, This should come to be a considerable part of the practice of each dentist—and it should be the service by which a substantial portion of his income will be earned. Practitioners who follow such a plan will have very few patients in whose mouths pus pockets will occur.

Palliative treatment should be applied in those cases in which pus pockets have formed, but are not bad enough to require the extraction of the teeth involved. It is not possible to give a definite rule by which the line may be sharply drawn between those conditions which demand extraction and those which contra-indicate this operation. More will be said on this point later.

If palliative treatment is undertaken, the first procedure should usually be the removal of deposits from the roots, if deposits are present. It makes little difference what instruments are used, if the operator is able to remove the deposits. A large number of scalers is not necessary, for it is believed that other means should be employed instead of scaling operations if there are deposits in positions of very difficult access. It is certainly of the greatest importance that each operator should develop the best possible finger skill.

The instruments should be sharp and the effort should be made to remove all the deposit and leave the root smooth. In doing this, as much as possible of the cementum should be left on the root. The removal of the cementum causes many teeth to become hypersensitive, so that thermal changes or even the mastication of food is painful. It should be borne in mind that there is no physiological provision for transmission of sensation through cementum. Therefore there should be no sensation transmitted through the pulp in scaling operations, so long as the cementum is intact. Sometimes acid formed by organisms growing within a pocket will soften the cementum, so that it is easily removed, or it may be removed by repeated scaling operations. One case has been presented in which the pulp, within the root-canal, was actually exposed by the too vigorous use of scalers.

If pain is caused in the overlying tissues by scaling operations, novocain may be injected. However, in such cases I have generally preferred to remove the bulk of the deposits, which can usually be done without much pain, at the first sitting, and then, by thoroughly irrigating the pockets with salt solution on two or three successive days, bring about sufficient reduction of the inflammation that the more thorough scaling can be done without causing pain.

Following the scaling, the case should be observed by the dentist until the inflammation has subsided, irrigating all pockets thoroughly at each visit. The patient should then be carefully instructed in the use of the rubber bulb syringe and should be impressed with the necessity of irrigation twice daily with normal salt solution. By this plan the pockets will be kept clean and free from accumulations or micro-organic growths, and the recurrence of deposits will be in large measure prevented. After the roots are once thoroughly cleaned, the irrigation by the patient becomes the most important factor in the prognosis of most cases, and its importance cannot be too strongly impressed. There should of course be an arrangement for subsequent examinations, and further treatment when necessary.

In a limited number of cases, the cleansing operations, and incidentally the scaling, may be simplified by cutting away the overlying soft tissue and thus materially reducing the depth of the pocket. This treatment is most frequently indicated for pockets on labial or buccal surfaces.

Time will not permit a discussion of the reasons for the abandonment of antiseptics in the treatment of these pockets. It need only be said that antiseptics were originally used here for the same reason that they were used in other infected cavities by surgeons, to inhibit the growth of the organisms. Today we should abandon their use for the same reason that surgeons have generally done so, because it has been found that they do more harm than good; that an antiseptic which will be effective against micro-organisms will also so inhibit the activities of the tissue that nothing is gained. By the use of salt solution, most of the organisms are washed away and the tissues are left in the best condition to destroy the remainder.

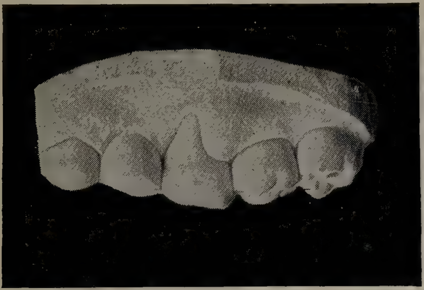


Fig. 17. Plaster model of case in which the tissue overlying a pocket on the mesio-buccal root of an upper first molar was cut away to reduce the depth of the pocket and facilitate the cleaning.

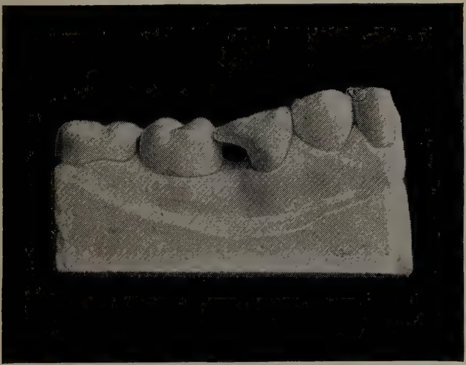


Fig. 18. A case in which the distal root of a lower first molar was amputated. The distal half of the crown of the tooth was also cut away, and a gold crown was made to restore the full occlusal surface.

This plan of treatment is quite simple, but is very effective if the co-operation of the patient can be secured. So long as the pockets are kept clean, they are practically well, and both the teeth and the health of the patient are conserved.

Radical treatment for these cases consists of extraction or root amputation. As a general statement, it may be said that we have gone too far in our effort to save these teeth. When so much of the investing tissue has been destroyed that the tooth is very loose, it should be extracted. If a tooth has deep pockets and is periodically sore enough to interfere with proper mastication, it should be extracted. If the formation of pus can not be controlled, the tooth should be extracted. In most cases, if the disease has progressed to denude the bifurcation of multi-rooted teeth, they should be extracted. Root amputation may be substituted for extraction in cases in which a single root of a multi-rooted tooth is diseased, while the other root or roots are not. The lingual root of the upper first molar offers the best opportunity for successful amputation. It often requires a very careful study of cases to come to a proper decision regarding extraction. We certainly should not be guided by the usefulness of the tooth in mastication alone, as many teeth which are serviceable are a decided menace to health.

FIFTH LECTURE

MANAGEMENT OF CASES

SYSTEMIC EFFECTS OF MOUTH INFECTIONS

In the previous lectures, we have discussed the several diseases to which the gingivae and peridental membrane are subject, considering the pathology and treatment of each separately. In many mouths several or all these conditions may be present at the same time. An accurate and complete diagnosis is therefore often difficult, as is the determination of the best plan of treatment. For this reason a definite system of making and recording examinations becomes a matter of first importance. In the clinics accompanying these lectures I have demonstrated a simple plan by which each area of inflammation may be recorded by a number, which will indicate the condition of the tissue, the position, and the cause. It requires a little experience to become familiar with any such plan, yet the advantage gained by having made and recorded such complete surveys of the mouth will fully compensate for the effort. The habit of doing this will sharpen one's observation and put one in position to lay out a comprehensive plan of treatment. Every area of gingivitis, the locations of deposits of both salivary and serumal calculus, the condition of contacts, the location and depth of pockets, teeth which are missing, those which are loose, and many other items are necessary to a complete record. In cases in which there are pockets, radiographs should be made for the additional information which they will give and to verify the instrumental examination. In some cases inquiry should be made into the general physical condition of the patient.

With all the facts obtainable, one is ready to lay plans for treatment. It should first be determined what teeth unquestionably require extraction, then those which should unquestionably receive palliative or preventive treatment. There may be several regarding which there is some question and oftentimes it will be wise to reserve one's judgment regarding these for a little time, possibly for several months, until the attitude of the patient towards the technic of mouth hygiene has been observed. It will be possible to retain, without menace to the health, teeth with tolerably deep pockets in one mouth, if the use of the syringe is faithfully carried out, while in another even quite shallow pockets will constitute a serious menace if they do not receive proper irrigation.

The problem of appearance, and that of replacing lost teeth to provide a means of proper mastication, must have consideration at the same time. Often it will be best to remove some of the ''doubtful'' teeth in order to give better abutments for a bridge, or if a denture must be made, there may be an advantage in extracting several such teeth.

The general attitude of our people in favor of saving every tooth as long as possible presents one other difficulty in the management of these cases. When it has been determined that certain teeth should be extracted, careful dipomacy must often be used in our advice to the patient. I have, on several occasions, given patients what I am sure was sound advice to the effect that they should have many or all of their teeth extracted, with the result that I did not see them again. We should always bear in mind the fact that the loss of the teeth is a serious thing in the life of most persons,.and some time is often required to bring them to a proper realization of the situation which confronts them. It is often best, therefore, first to suggest and later to state definitely what seems best, with our reasons.

The studies by medical men in recent years have brought to us another proposition for very serious consideration; viz., the relation of the local foci of infection to many serious systemic diseases. This relationship has been recognized by a few men for many years, but was not prominently before either the medical or the dental professions until Hunter, of London, wrote his famous article in 1911.

As early as 1891 our own Dr. W. D. Miller wrote as follows: ''During the last few years the conviction has grown continually stronger among physicians, as well as dentists, that the human mouth, as a gathering place and incubator of pathogenic germs, performs a significant role in the production of varied disorders of the body, and that if many diseases, whose origin is enveloped in mystery, could be traced to their source, they would be found to have originated in the oral cavity.''

Dr. Hunter wrote his first paper in 1900, but it was not until eleven years later, after he had seen hundreds of patients improve or fully recover from those diseases which are now recognized as occuring secondary to local foci, as a result of practically no other treatment than the clearing of the mouths from infection, that he wrote a scathing article which brought both professions to their feet. Among other things, Dr. Hunter said in this paper: ''Sepsis in medicine therefore ranks, in my experience, as the most prevalent and potent infective disease in the body. It therefore deserves the particular attention of the whole profession as much as it has hitherto received their particular neglect. It requires this attention at the hands of every branch of the profession.'' Dr. Hunter's investigations seem to have been confined principally to clinical observations and case histories, yet they are of great value because of the large number and variety of cases reported.

The studies of Dr. Frank Billings and the group of men associated with him in Chicago have been along more scientific lines, and have given unquestionable proof of Dr. Hunter's observations. Dr. Billings says: ''Systemic disease due to a focus of infection anywhere is probably always hematogenous. The study of infected tissues of experimentally inoculated animals, and the infected muscles, joint tissues, lymph nodes proximal to infected joints, nodes on tendons, etc., of patients, yield specific bacteria, and histologically there is found embolism of the small and terminal blood vessels. Local hemorrhage and endoarterial proliferation result in interstitial overgrowth, cartilagenous, osseous, vegetative and other morbid anatomical changes, dependent on the character of the tissue infected.'' This one quotation will suffice to impress the fact that Dr. Billings' investigations have been exceptionally thorough.

Dr. E. C. Rosenow has done most of the bacteriological work for Dr. Billings' cases and his investigations have demonstrated that many changes occur in the morphology of organisms in accordance with their environment, also that they develop as yet unexplained affinities for certain tissues. This was proven by the use of fresh cultures from four groups of cases; appendicitis, ulcers of the stomach, cholecystitis, and arthritis. The cultures were injected into veins of dogs and rabbits, and in each group a very large majority of the animals developed inflammations of the very same tissues as those from which the cultures were made, while there were inflammations of comparatively few of the other tissues.

In the light of our present knowledge, we are justified in making the following summary of the relation of mouth foci to general systemic conditions:

1. The mouth contains a large variety of micro-organisms, which may be divided into two groups; those which are normal or constantly present, and those occasionally or frequently found.

2. Conditions in the mouth are such that slight inflammations of the gingivae are of frequent occurrence, being present in about ninety-five per cent of mouths of adults.

3. These slight inflammations, if untreated, may gradually progress to chronic suppurations. The suppurations are caused by organisms normal to the mouth.

4. All organisms in the mouth, whether normal or accidental, have access to the blood stream through the soft granulations.

5. The normal resistence tends to prevent systemic effects and is apparently successful in the large majority of cases.

6. The transmission of infection from the primary focus is principally hematogenous.

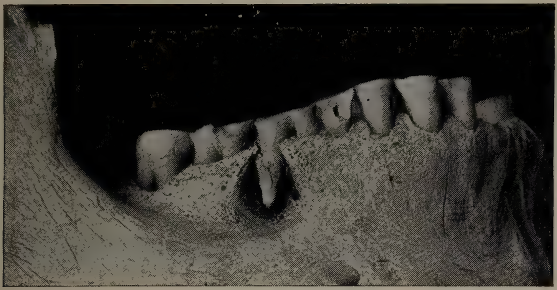


Fig. 19. Lower jaw of a Flat-Head Indian from Columbia River, Oregon, showing destruction of bone by a chronic alveolar abscess about the distal root of the first molar. The bone about the first molar of the opposite side is in practically the same condition. This is typical of the injury which occurs.

7. The primary focus is characterized by suppuration, while the secondary lesion is non-suppurative. Therefore the secondary lesion is not caused by the principal organism of the primary focus, but by other organisms which enter the primary focus with or after the pus producer, and thus gain access to the circulation; or else the morphology of the pyogenic organism is changed if it produces the secondary lesion.

8. The organisms entering the circulation through such foci appear to have an as yet unexplained tendency to locate in particular tissues.

9. The secondary effects include a very wide range of conditions. Chronic arthritis, endocarditis, nephritis, cholecystitis, ulcers of the stomach, and appendicitis are the most frequent definite lesions. General impairment of health and vigor, with or without recognizable lesions, is common.

10. The secondary effects are usually insidious in their onset and progress and, when cases present to physicians for treatment, are often difficult of management.

11. It is imperative that the primary foci be eliminated, regardless of the apparent systemic effect or lack of systemic effect.

12. For the reason that the mouth contains the primary foci in the large majority of cases, a great opportunity is open to the dental profession to prevent grave systemic disease.

The chronic foci of the mouth may be divided into three groups: (1) Deposits of salivary calculus. There may be included in this group all fillings, crowns or bridges which impinge on the soft tissues and keep them in a constant state of irritation, in somewhat the same manner as does a deposit of calculus. In all cases of this group the rule is that the systemic danger is removed with the relief of the pressure contact on the soft tissue. (2) Pus pockets alongside roots resulting from a suppurative gingivitis. (3) Chronic alveolar abscesses. Each of the latter two causes the detachment of the peridental membrane from the cementum, and the denuded, pus-soaked cementum is the chief factor in maintaining the chronicity of these.

Today a thorough search for mouth infection is usually undertaken only in cases in which secondary symptoms are manifest, and generally after the physician has been consulted. We know that many such cases will not be benefited by the removal of the cause at this time, because the secondary effect is already too well established. May I suggest that the highest duty of the dental profession today is to search for and eliminate these foci before secondary lesions are manifest. If a minority of these foci are known to have caused serious secondary effects, the majority should be eliminated while there is the opportunity to protect the health. This is the opportunity which is before the dental profession today. Such men as Billings, Osler, Mayo, Hunter, and others have expressed it as their belief that the majority of the secondary lesions are from primary foci in the mouth, which means that the dental profession can prevent these diseases if they appreciate the situation and seize the opportunity.

In giving this course of lectures, it has been my endeavor to stimulate your interest in this subject. What I have presented is necessarily superficial and must be supplemented by an extended study of what has been written, together with careful observation and application in daily practice. If I have set some of you to thinking, so that as time passes your appreciation of these conditions will be better, I shall have accomplished my purpose.

UNIVERSITY OF CALIFORNIA
COLLEGE OF DENTISTRY

EXTENSION LECTURES
4

HAND-CARVED PORCELAIN SHELL AND OTHER CROWNS, TOGETHER WITH AMALGAM MODEL TECHNIQUE FOR CROWNS AND INLAYS.

BY

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HISTORY

Porcelain shell or jacket crowns are by no means new. The literature of dentistry for the last twenty-five years devotes considerable space to their construction and use.

In the *Dental Cosmos,* Dr. Capon of Philadelphia and others have reported periodically their success with these crowns, and at no time have they receded from their favorable opinion of them.

The original work and development of this type of restoration was done by Doctor Land of Detroit, many years ago, and later modified by Doctor Land and Doctor Spaulding into what has become known as a porcelain shell. This is, essentially, a crown baked on a platinum-foil matrix, which foil is later removed and the crown cemented over a conical-shaped tooth stump. The work for many years was largely confined to peg-shaped lateral incisors, except in the hands of a few men, but since the search-light of the X-ray has been thrown upon our root fillings and the dental and medical professions have demonstrated systemic lesions that may arise from poorly treated and improperly filled roots, there has arisen throughout the country a demand for methods of operative procedure that will save vital pulps whenever possible.

It is probable that the reason the porcelain shell never came into popular use was that there are technical difficulties associated with its proper construction. The method about to be illustrated was developed with the idea of eliminating the uncertainties of handling porcelain in these delicate restorations, and so making it possible for the general practitioner of dentistry to handle this work as regular routine, rather than to send his patient to a specialist.

WHERE INDICATED

(*a*) On a peg or rice-shaped laterals.

(*b*) Badly broken down or extensively decayed teeth with vital pulps, where any other type of porcelain crown would demand devitalization.

(*c*) Devitalized teeth where any uncertainty exists as to the healthy condition of the roots, which condition might later make the easy removal of the crown an advantage.

(*d*) Badly eroded or undeveloped teeth.

(*e*) Lower incisors, on account of their roots being small for dowels.

SUMMARY OF ADVANTAGES

(*a*) The saving of pulps, avoiding the uncertainty of root fillings in vital teeth requiring crowns.

(*b*) The avoidance of gingival or pericemental inflammation, as frequently found under banded crowns. Gold crowns on teeth prepared as for a porcelain shell cause less gingival irritation than when mounted in the usual way, but more than the porcelain.

(*c*) Appearance. No other artificial crown presents so natural an appearance.

(*d*) Strength; which is much greater than popularly supposed. The stress of mastication being directed against a larger surface than when the tooth crown has been cut away to the gingival, the root is more fully protected from fracture. The unmounted crown appears to be, and is, very fragile, but once mounted and supported at all points by the cement and stump it is very strong. For several successive years the same porcelain shell mounted on an extracted root was driven into a pine bench-top as an illustration to the students of the strength of these crowns when mounted.

(*e*) No danger of the root being split or perforated, as with dowel crowns.

(*f*) Limits the recurrence of caries because the cement line is almost eliminated and is also protected by healthy gingival tissue.

(*g*) Ease of removal if necessary, and ease of replacement if models are preserved, as they should be.

COMPARATIVE DISADVANTAGES

None but those due to the operator's lack of technical skill and experience and the inability of some patients to pay for the time consumed.

VITALITY OF PULP

No fear need be felt for the vitality of healthy pulps if certain precautions are carefully observed during the preparation of the stump and until the crown has been finally cemented. Excepting peg laterals and other undeveloped teeth, teeth requiring single crowns are usually badly broken down by caries on both mesial and distal and part of the occlusal surfaces. The resulting cavities have often been filled for some time previously so that the pulp has receded to a considerable extent. The remaining portion of the stump requires little more than the removal of the enamel on the lingual and labial sides, with no deep cutting such as would be necessary for the retention of fillings. The precautions to be taken are that at no time the tooth be overheated in grinding, especially when the work is done under an anesthetic, always using a stream of water, and then that, before dismissing the patient, the stump be thoroughly sterilized, varnished, and covered with cement (not gutta percha) to which an antiseptic such as thymol has been added.

If the vital tooth is in a conspicuous position in the mouth a temporary crown made by hollowing out a detached post crown for the anterior teeth or the use of an old gold crown or even a copper band filled with cement for the posterior is indicated, as this serves to hold away the gum from the ledge lying under it and so facilitates the subsequent cementation as well as prevents irritation of the gums lying over the shoulder itself. Leaving teeth in this condition removes the chief occasion for haste in setting the final crown, and makes it possible to carry on more leisurely the necessarily involved laboratory technic.

Experience has shown that teeth that are quite sensitive before cementation of a porcelain shell soon become entirely comfortable even to applications of cold water, due to the very high insulating properties of the porcelain.

With bell-crowned bicuspids and molars, it is frequently unnecessary to extend the lingual shoulder further gingivally than to the greatest diameter of the tooth, and in many other cases not much more than the enamel is removed.

OPERATIVE TECHNIC

The operative technic varies with the location of the tooth in the arch, the amount of tooth substance already lost, and the position of the adjoining teeth. Briefly, the object is to reduce the stump to a somewhat conical shape, with its base toward the gum; which base is surrounded by a shoulder or ledge about 0.5 mm. wide and located just under the free margin of the gum. Of course, where deep cavities exist these need only be cut out or filled with cement so as to present a uniform tapering surface, toward the incisal or occlusal, so that an impression of the stump may be withdrawn without distortion. The tapering of the sides is easily done with knife-edged stones, Hall's flexible disks, mounted cylindrical stones, chisels, and burs, but great care is necessary in the preparation of the shoulder. For this purpose square and fissure burs of small size, Miller's cylindrical stones, safe-sided end-cutting burs and Black's hatchets and chisels are all used. The ledge as well as the stump should be left with a surface as smooth and highly polished as practicable to facilitate the withdrawal of the impression. After shaping up the stump, but before cutting the ledge, a copper band approximately as long as the adjoining teeth, or at least longer than the stump, should be fitted fairly closely and shaped to firm contact with the proximate teeth, carefully festooning out for the curvature of the gum. One of the manufactured copper bands used for seamless crown work can usually be found suitable for this purpose.

After the stump is prepared, the copper band is filled with perfection modeling compound, thoroughly softened in hot water and pressed over the tooth. Two syringes, one with cold and one with hot water, should be ready. As the compound chills, a stream of warm water is thrown upon it, keeping it soft until it has pressed the gum away to take the impression of the root beyond the shoulder. The band may be removed for examination, but if this be done it is again warmed with hot water when replaced on the tooth and forced up a little farther than before.

Now, hold the compound firmly in position and chill with the cold-water syringe. Any excess of compound forced over the sides of the band either gingivally or incisally is now removed and the assistant directed to continue dropping cold water on the impression while a bridge impression tray is being filled with plaster mixed with *cold* water and an excess of salt. A plaster impression of the copper band in position and of the adjacent teeth is now taken and removed as soon as brittle, before the heat caused by the setting plaster has softened the modeling compound. The copper band will usually remain on the tooth. It is again chilled, then removed, and a wax bite is taken.

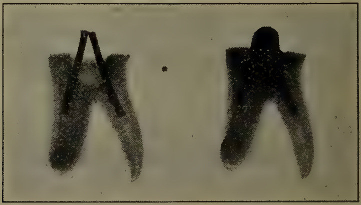


Fig. 1

The next step is the selection of the proper colors of porcelain. When the adjoining teeth can be matched from a sample of one of the manufacturer's guides, this is all that is necessary, but when this cannot be done the color most nearly correct should be chosen and a memorandum made as to such changes as may be demanded. The temporary crown, before suggested, is now set with a temporary cement and the patient may be dismissed. I usually allow one hour for the operative technic just outlined.

It is an advantage in putting porcelain crowns on many molars, particularly uppers, where the roots diverge to a considerable extent, to be able to insert the necessary dowels without running the risk of root perforations, or weakening them by attempting to make the canals parallel. This is easily avoided by setting dowels in the individual canals with cement, allowing them to extend to, and their ends to meet, well outside the pulp chamber as shown by the radiograph. See Figure 1. The pulp chamber is then slightly undercut and packed with amalgam, which is also carried up around the dowels to give them some conical or pyramidal form. From this point the procedure is as for a porcelain shell. Occasionally pulp chambers are so deep and the tooth so strong that little more, if any, attachment is needed than the amalgam alone.

At a subsequent sitting, after the amalgam has set, the impression is taken and the crown made as for a porcelain shell.

If it ever becomes necessary to remove a crown of this type it is easily done by cutting a groove in the porcelain with a knife-edge stone and splitting it. The amalgam can now readily be drilled out and the round tapering dowels, whose ends protrude from the pulp chamber, be removed separately with pliers.

Impressions for Other Types

The only variation from this method when taking an impression for dowel crowns is that, instead of filling the copper band with modeling compound *before* placing on the root, the band is first adjusted to the root and softer compound is packed firmly into it with pluggers until it has been forced into every irregularity and well into the root or pulp chamber. It is now chilled. A root plugger smaller than the root canal as enlarged for a dowel is heated in the flame and used as an explorer to find the canal openings prepared for one or more dowels. The previously fitted dowels are now warmed in the flame and pressed home through these openings. In going to their proper position, they will carry with them compound so that an accurate impression of the root canal is taken as well. After chilling, the plaster impression is taken as before. Upon the amalgam model made from this impression, any type of crown desired may be constructed, and made to fit more accurately than if the work were all performed in the mouth, as shown by the models. If through breakage of the porcelain, decay of the root, lack of contact, recession of the gum, change of color, or other causes, it becomes necessary to replace the porcelain of a dowel crown when the dowel is firmly anchored in the root, the root is prepared as desired without removal of the dowel, which should, however, be made slightly tapering by grinding, or by the addition of cement or amalgam. The impression is taken exactly as for a porcelain shell. The laboratory procedure will be shown later.

M. O. D. CAVITIES

To take an impression of an M. O. D. cavity in a bicuspid or molar, the copper band is fitted roughly and trimmed away so that it will not pass farther gingivally on the labial or lingual surface than the greatest diameter of the tooth. Care should be taken to see that the copper band presses close against the contact points of the proximate teeth. To take the impression, the band is placed in position and soft compound forced in with pluggers, while a stream of water is syringed onto the tooth, sufficiently hot to keep the compound soft and workable. A small piece of compound is added to take the occlusal surfaces of the adjoining teeth, the whole chilled and removed without taking a plaster impression. A small wax bite should be obtained.

As shown by the models, from this small and quickly obtained impression accurate models may be made that will show perfectly the cavity and tooth in amalgam, and the occlusal and contact points in plaster. The amalgam may be removed from or replaced in the plaster model at will, making the formation and withdrawal of a wax pattern a simple and accurate procedure. The gold casting may be forced into the model by placing it in the swaging device and swaging, and the inlay closely finished and polished while on the model, resulting in a much better fit than can possibly be obtained by working directly on the tooth.

A little experience will soon suggest ways of taking impressions of any cavity where a model would be an advantage, but one fact should be strongly emphasized, namely, that in order to get an accurate impression with modeling compound the material must be worked while thoroughly softened, and must be confined with some sort of matrix, such as a copper band, so that it cannot escape when packed in under heavy pressure. This cannot be accomplished through the use of small cavity impression trays.

BRIDGES

In the construction of bridges, a plaster impression of the copper band —modeling compound impressions of the abutments may be taken together and the models made therefrom so handled in the laboratory that no further impressions are necessary, the bridge being completed on the original models. Where inlay abutments are to be used there is far less danger of error in replacing the copper bands in the plaster impression than in replacing the inlays in a plaster impression taken while they are in the teeth. Another advantage of working on the amalgam models is that the assembled bridge may be removed for soldering and replaced on the models to be adjusted and finished. If any shrinkage or warpage has taken place, or the abutments are so far out of parallel that the bridge will not go to place, it is quite evident at this time and can be corrected or plans made for a proper change in the abutments.

Porcelain Inlays

Amalgam models are especially indicated in porcelain inlay work in labio-gingival cavities. The gum is easily forced away by the modeling compound and so a clear field of operation is obtained on the resulting model.

In complicated cavities where the burnishing of a matrix is a difficult operation, it may be greatly simplified by a combination of burnishing and swaging on an amalgam model. In fact, the rule holds good that the more difficult the operation of making an inlay or a crown in the mouth, the greater the necessity for a correct laboratory model; and after ten years' experience in developing and using this technic I can assure you that a little time spent in getting correct impressions is well repaid in the ease and certainty of subsequent procedures. For those having a laboratory assistant much time is saved, the laboratory steps becoming mere routine; and any competent office nurse can soon become quite proficient in the making of the amalgam and plaster models.

To Summarize

The important points to be observed in taking cavity or root impressions are:

1. When inlay or crown is to have contact with proximate teeth, the copper band must be firmly in contact with the contact points of these teeth.
2. The compound should always be soft for taking impressions and always chilled when being handled at other times.
3. All excess should be trimmed away so that overhanging particles will not stick to the plaster impression.
4. The compound must always be thoroughly confined by a matrix.

Laboratory Technique

This method was developed with the idea of having as much of the work as possible done in the laboratory, either personally or by an assistant. In the laboratory there is no fussy patient to annoy; no bleeding gums to bother; in fact, no gums at all, because they may be trimmed away from the plaster model or the amalgam model removed entirely; as much time as necessary may be used, at odd times if more convenient; and, as will be shown, it is possible to do everything that can be done in the mouth with greater ease, greater comfort and much more accuracy in the laboratory. If a failure results it is much easier to correct (unless it occur in the impression or model), making an extra visit of the patient unnecessary. The time used in obtaining the models is more than made up in the following procedures:

Construction of Models

The construction of the models is divided into the following steps, which should be followed out exactly as outlined for porcelain shell crowns. Variations for inlay and dowel crowns will be mentioned later.

1. Assemble and varnish plaster models.
2. Fill copper band with moldine form approximately as amalgam is wanted, which should be as shown by Figure 2.
3. Invest copper band containing moldine in plaster by setting moldine on glass slab or other smooth, flat surface and covering the whole with small mix of plaster.

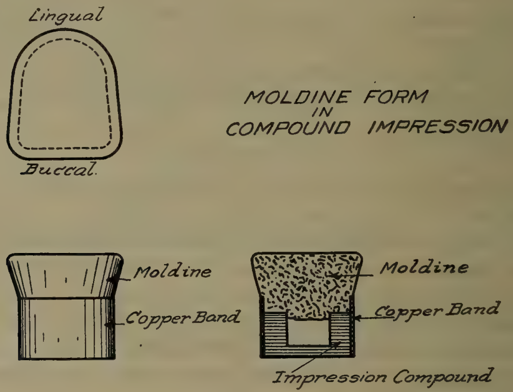


Fig. 2

4. When plaster has set, pick and wash out moldine and pack amalgam in its place. This step is not easy. The first application of amalgam should be quite soft and carefully rubbed into all parts of the impression in small pieces with smooth pluggers. As soon as the impression face is covered, drier amalgam is heavily packed with as large serrated pluggers as can be used, up to the level of the opening in the plaster, and set away to harden (Figure 3).
5. When the amalgam has set, cut away the plaster investment, using care not to disturb or mar the modeling compound, and trim the amalgam model so that the bottom is perfectly flat and smooth, so that the sides of the base have no undercuts and the base is wedge-shaped with its greatest width labially, and pyramidal with its base downward. The form just described should have been outlined by the moldine first placed in the copper band. The base should also be highly polished on all sides.

6. Place copper band now filled with amalgam in place in plaster impression.

7. Run plaster model and when set, separate impression, warm copper band and remove it together with the compound.

8. Adjust wax bite and model on articulator and varnish both model and the occluding teeth. We now have a ''master model,'' that is, a perfect reproduction of the tooth to be crowned and the adjoining teeth.

9. Take plaster or modeling compound impression (plaster preferred) of the ''master model'' and also wax bite, with the amalgam model in place.

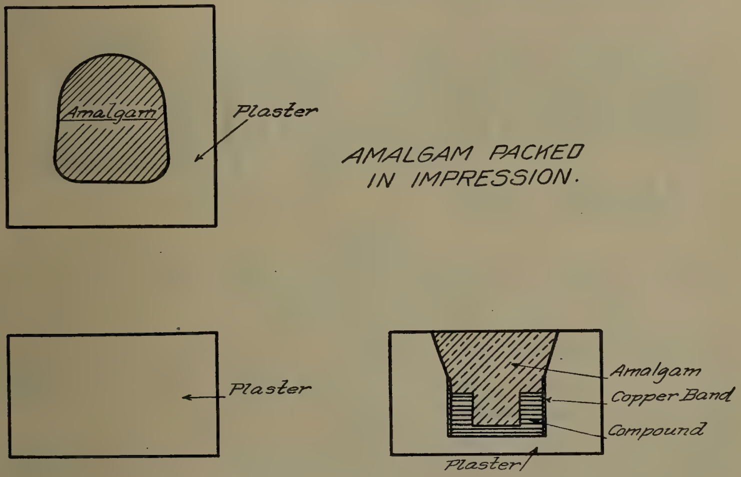


Fig. 3

10. Remove amalgam model by sliding out labially, the plaster having been cut away for this purpose, and place it in the plaster impression, varnish and make ''working model'' and bite. Mount on an articulator as before.

11. Remove the amalgam model as before and adapt by burnishing and swaging a platinum matrix of 1/1000 foil, carrying the foil half way down the sides of the pyramidal base.

12. Place the model, with the matrix in position, on a glass slab and cover with plaster.

13. When the plaster has set, remove the amalgam with sticky wax and fill the platinum matrix with alundum cement. Before packing the alundum cement, a small edge of the platinum foil is turned in from the

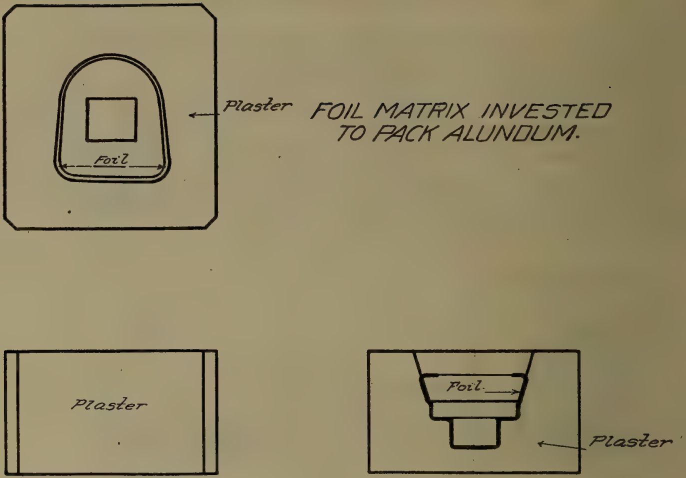
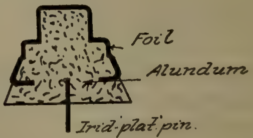


Fig. 4

plaster so that it will be firmly imbedded in the cement. Finally, insert a round iridio-platinum wire, about 17 gauge, in the center of the base, allowing it to protrude about one-eighth of an inch (Figure 4).

14. Dry immediately, if necessary, but slowly over a bunsen burner, finally bringing up to a red heat with the blowpipe. If there is no hurry, allow the cement to dry before applying heat. Then remove the plaster and bake the platinum-covered alundum model in an electric furnace at approximately 2600° F. We now have a foil-covered alundum model that has a wire firmly imbedded in it for ease of handling in the pin vise and furnace, and that will fit both the "master" and the "working"



FOIL COVERED ALUNDUM MODEL

Fig. 5

model, when a slot is made in the plaster to receive the wire (See Figure 5). The contacts of the proximate teeth on the working model are now cut away to allow for shrinkage of the porcelain, approximately one-fifth of the mesio-distal diameter of the finished crown. After each baking the alundum base and crown are tried on the ''master model'' for guidance as to the exact contact.

When the crown is finally baked, the iridio-platinum pin is removed from the base with pliers, and the alundum is removed by grinding out with small stones, under water. It can be dissolved out, or at least softened, by the addition of one drop of hydrofluoric acid left in the crown for five minutes, the outer surface being first covered with wax for protection.

The impression obtained of a root containing a dowel already set is handled in the laboratory exactly like a porcelain shell except that if the crown end of the dowel be round it is easier and will be stronger if its place in the impression be filled with a German silver wire of the proper size, allowing it to extend into the amalgam.

LABORATORY TECHNIQUE FOR DOWEL CROWNS WITH CAST METAL BASES

The first variation from the porcelain shell technic is in the application of the moldine to the root impression for the formation of a plaster matrix or form, into which the amalgam is packed to make the model.

In these cases, one or more dowels are present, necessitating a deeper model, and while the porcelain shell model was formed with a view to its exact duplication in alundum, this step is not required nor is but one plaster model, because it will not be necessary to trim or mutilate it, to allow for shrinkage of the porcelain body. Therefore, instead of making the amalgam model pyramidal with the base down, we make it pyramidal with the base up; in other words, tapering toward the root end. This model is removed from the impression occlusally by drilling a small hole through the plaster opposite the root end, and gently prying the model out (See Figure 6).

A few suggestions will be offered as to accurately adapting the cast base of a manufactured porcelain tooth of any suitable kind:

1. Grind the porcelain to shape, arranging for a shoulder at least as high as the contact points on the mesial, distal and lingual sides of the tooth if a bicuspid or molar. This will form a box in the casting to support the porcelain and provide an easy means to add to the contact points if necessary by the addition of a little solder.

2. Swage a matrix of 1/1000 platinum foil over the root, forming a band, if desired, and insert the dowel or dowels in their proper positions, fastening them with a little sticky wax.

3. Swage a similar foil matrix over the porcelain; place softened inlay wax on the root while on the model and set porcelain in proper position.

4. Remove the amalgam model and finish wax in desired form.

5. Remove waxed-up crown from the amalgam model—lift out porcelain and paint both exposed surfaces of platinum with a thin mixture of whiting in alcohol.

6. Invest and cast into a hot mold so that the gold will flow readily around the dowels.

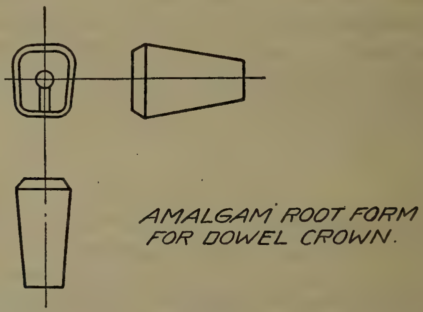


Fig. 6

Variations for other types of crowns suggest themselves, the fundamental steps for obtaining fit and adaptation being identical.

Laboratory Technic for M. O. D. Cast Inlays

The amalgam model base is first shaped as for the dowel crown. Plaster is now poured into the impression of the occlusal surfaces of the adjoining teeth and closely against the sides of the copper band, which you will remember was in close contact with the contact points of the proximate teeth. This establishes the mesio-distal diameter. After removing the band and compound the little wax bite is adjusted and poured. After separation we now have a model correctly showing contact and occlusion. Fill the cavity with inlay wax, carve, invest and cast the fillings.

It is unusual for one of these castings to go readily into place, in fact almost impossible without spreading the filling a trifle at the gingival. After removing any apparent roughness on the cavity side of the inlay, place it in the model, mount in the swaging device and drive to place with unvulcanized rubber. After trying in the tooth and ascertaining if there is any deviation from the amalgam model, there being none, the inlay may be burnished, finished and polished on the model more advantageously than in the mouth, especially at the gingival margin.

Porcelain Technique Bodies

During the past few years so-called low fusing porcelains, meaning those porcelain bodies that will fuse in five minutes below the melting point of pure gold, have gradually been abandoned by many practitioners for so-called high fusing bodies that require a platinum rather than pure gold base upon which to fuse the material. More recently still the tendency is to raise the fusing point farther, so that while a short time ago a porcelain body fused at 2300° F. was considered high fusing, now bodies fusing in a few minutes around 2600° F. are in common use.

These higher fusing bodies are apparently stronger, shrink less in firing and are much more transparent and life-like in appearance. There is also less liability to over-fuse and great permanence of color is therefore to be expected. There are no unusual difficulties connected with their manipulation, excepting the strain on the electric furnace. Through changes in the construction of furnaces, such as the addition of larger resistors and the development of muffle and investing materials of greater purity, it is probable that the manufacturers will keep up with the procession and supply us with our needs in this direction. With our present furnace a great deal can be done to save the muffle winding by using a heavy insulated door, such as is supplied with the Hammond furnace, keeping the opening closed as much as possible when baking at high temperatures and allowing a little more time rather than great heat to do the baking. It is quite possible, but impracticable, to fuse so-called 2600° F. porcelain on pure gold if given enough time.

Foundation Bodies and Enamels

Crowns made under this method are finished in two or three bakes, and the natural shrinkage of the porcelain is perfectly controlled without the use of bodies of different fusing points, so that the use of an enamel body is eliminated except in cases where an addition is to be made after the platinum matrix has been removed.

Shrinkage and Density

Shrinkage and density are closely related, the former depending to a great degree upon the latter. Dense porcelain is to be obtained only by the observance of certain rules.

1. The body should be well spatulated to a thick creamy consistency and as much air as possible rubbed out.

2. It should be applied to the work in small amounts, each application being thoroughly condensed before more is added.

3. The work should be carried forward steadily, always remembering that dry body is not necessarily dense body and that the moisture dries out very rapidly in the air without the application of other means of absorption.

In carved crown work, burnishing or ironing the body into form is better practice than to attempt any extensive jarring to produce density. The alundum bases are quite absorbent. Therefore they should first be moistened with a drop of water before any body is applied, to prevent too rapid drying.

Obtaining Color

All crowns contain some proportion of yellowish hues, and most crowns can be made by the combination and blending of the proper hue of yellow with one other color. To obtain the selection, analyze the tooth taken from the guide by comparing its different sections with the color guide of the body to be used and make the proper choice. Now apply the yellow, building up the tooth approximately like the dentine and cover with the second body as an enamel, allowing them to overlap and blend at the right place. After the crown is built up in more or less block shape, it is carved to form and occlusion. Dry out and bake.

More particular details as to the handling of the porcelain will be gone into during the laboratory periods. Charts will also be displayed giving an analysis of certain color guides, but these are considered as being of little benefit to the operator who has an eye for color; and he who has not would better serve his patients by not attempting porcelain work.

Method of Using a Facing

This method is simple and appeals particularly to the inexperienced, but only in exceptionally favorable cases does it produce a crown of as fine appearance as the hand-carved. One of the chief factors adding to the lifelike appearance of the hand-carved porcelain shell is found in its very imperfections of form, whether caused intentionally or otherwise, and these imperfections are never found in manufactured teeth. Another disadvantage in the use of facings for a porcelain shell on vital teeth, where the labial plate is necessarily quite thin, is that the colors of a facing are blended by laying one color over another, so that in grinding out the facing to great thinness most of the underlying color is ground away and there is no opportunity for strengthening it by further additions.

If, however, a favorable case presents itself, the facing of any kind suitable is ground away on the back until it will permit of adjustment to the labial contour, particular care being taken to let it rest against the stump and on the labial gingival ledge at some point, fastening it in position by cementing it to the base at the labial gingival with sticky wax. Now add the body to the lingual, making the first application thin and jarring down until the body has been thoroughly packed under the facing around the labial ledge and in all places inaccessible for burnishing. The building up and carving now goes forward as in a carved crown, using drier porcelain. Before insertion in the furnace most of the wax used to hold the facing in position temporarily is removed with a hot spatula. The rest will be readily burned away without injury to the porcelain, and the crown from here on is handled in the usual manner.

ALUNDUM

Alundum is a refractory material made by fusing the mineral bauxite, a natural hydrate of alumina, or a pure aluminum oxide, in an electric furnace of the arc type. Until the invention of the process for the manufacture of alundum, bauxite was considered infusible. Most of the impurities found in bauxite are removed by certain processes of purification.

The manufacturers give it a melting point of 2050° centigrade (3722° F.) and that of bonded alundum, or alundum cement, as slightly below this. The thermal conductivity of bonded alundum is stated as being 2.1 times that of ordinary fire brick, and 1.6 times that of chemical porcelain; hence its great value in electric furnace muffles.

The alundum cement used in this work is alundum to which a ceramic binder has been added. A mass the size of a molar tooth shows no shrinkage or expansion. Porcelain may be baked directly on it without any injury to the porcelain whatsoever, but after fusing they are very difficult to separate.

The cement, which comes as a dry powder, is mixed with water to the consistency of thick mud. It is better, but not necessary, to allow it to dry before applying heat. It is not real cement because it does not set until considerable heat is applied, vitrification taking place at about 1000° C.

Alundum cement forms to be used in porcelain work should be previously baked to the fusing point of the porcelain so that any gases that might be formed at the higher temperature be first driven off.

The cement is valuable for investing the platinum matrix for a porcelain inlay, as it will thoroughly control shrinkage and preserve its form while applying and baking the porcelain, and for making small stands to support work while in the furnace. After repeated firings, but within certain limitations, it becomes harder.

Of the different grades manufactured by the Norton Company of Worcester, Massachusetts, the one known as R.A. 162 is the only one I have tested that answers all our requirements.

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